2007

Dynamic Speed Monitoring System Effectiveness On Sharp Curves

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DYNAMIC SPEED MONITORING SYSTEM EFFECTIVENESS ON SHARP CURVES

by

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B.S.C.E. University of the West Indies, 2004

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Civil and Environmental Engineering
in the College of Engineering and Computer Science
at the University of Central Florida
Orlando, Florida

Fall Term
2007

ABSTRACT

The design of rural interchanges is of critical concern due to the need for the safe transition of vehicles from one high speed roadways to another and vice versa. This transition is accomplished by entry and exit ramps of various forms. The southbound entry loop ramp at the US 27/ US 192 trumpet interchange in Polk County, Florida does not provide such safe transition since historically there has been a high incidence of vehicular off-tracking. The geometry of the southbound entry ramp coupled with high approach speeds are two of the contributing factors. Due to the high cost of interchange modification and ramp realignment, one approach to increasing safety at the interchange is to decrease approach speeds (assumes that speed is a surrogate measure of safety) utilizing a Dynamic Speed Monitoring (DSM) system.

The objective of this thesis was to test the effectiveness of such a DSM system at reducing vehicle speeds at the rural US 27/ US 192 trumpet interchange in Polk County, Florida. The system tested was a solar powered, radar based, wireless speed warning system which potentially could be used at traffic locations where it is difficult to secure power and to extended wires. The Measures of Effectiveness (MOEs) for the system were the reduction in mean and variance of speed along with the proportion of vehicles in the higher speed ranges after system implementation. This thesis describes the testing of the DSM effectiveness and involves the documentation of the experiments conducted, the data collected and the analysis of the results.

Speed data was collected Before and After installation of the DSM system at two points preceding the southbound entry ramp. Approach speeds were collected at a point 250 feet in advance of the southbound entry ramp curve (also the detection zone of the DSM system radar)

and PC speeds were collected at the Point of Curve of southbound entry ramp. Various data sets were analyzed in order to ascertain the systems effectiveness during the day and night, weekdays and weekends, various time periods during the day, and within various speed ranges.

The Approach and PC data analysis indicated that the DSM system significantly (at the 95% confidence level) reduced speed mean and variance and increased speed limit/ advisory speed compliance. The Approach mean speed was reduced by 3.58 mph and the PC mean speed was reduced by 1.57 mph. The Approach speed variance was reduced by 3.34 and the PC speed variance was reduced by 0.70 mph. Approach speed limit compliance was increased by 22.27% and PC advisory speed (35 mph) + 5 mph compliance was increased by 11.56% (it was apparent that motorist were utilizing speeds above the advisory speed to navigate the curve). In general, the effectiveness of the DSM system was diminished on weekends as well as during the late night and early morning (12 AM to 7 AM) time periods. This suggested that when there were lower volumes and when motorists' perceived that speed limit enforcement was not as likely, the DSM system effectiveness was reduced. The DSM system resulted in a reduction in the percentage of vehicles utilizing the higher speed ranges (> 45 mph). There was a 62% average reduction in the vehicles that utilized the speed ranges above 57 mph for the Approach data and there was a 36% average reduction in the vehicles that utilized the speed ranges above 45 mph for the PC data. The DSM system resulted in a shift in the distribution of speeds from the higher speed bins to the lower speed bins Before and After installation.

To Genella Dass

For Writing “Focus”

ACKNOWLEDGMENTS

I would like to express my gratitude to my advisor Dr. Amr Oloufa. Without his valuable guidance and constant support this thesis would not have taken its present shape. I would like to acknowledge the support of Dr. Essam Radwan and Dr. Mohamed Abdel-Aty to the project fulfillment. I would like to express my appreciation to Dr. Yasser Hosni for his help as a Co-PI on this project. I also would like to thank Dr. Anurag Pande for his assistance. I would like to acknowledge my student colleagues Sami, Noor, Abishek, Vinayak and Vikash for their continuous support and assistance throughout the study process. I would like to thank my family and dearest Genella for the support and encouragement they have always given me. I would also like to thank Dr. Madaniyo Mutabazi at UWI for first introducing me to the field of transportation engineering.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 FDOT-UCF Project Background

In April 2007, the Center for Advanced Transportation Systems Simulation (CATSS) at the University of Central Florida began a research project (BD-548-15) for the Florida Department of Transportation (FDOT), District 1 to test the effectiveness of a solar powered, radar based, wireless system to monitor traffic on rural roads (rural typical section). The westbound to southbound ramp of the US 27/ US 192 Interchange in Polk County was selected by District 1 for further study because it was a historically crash prone location. This thesis presents the findings of the study.

1.2 Dynamic Speed Monitoring

Dynamic Speed Monitoring (DSM) is a technology available to transportation engineers to reduce speeding on highways. In theory, DSM works by informing passing vehicles of their speed causing drivers respond to this visual stimulus and in so doing improve speed limit compliance. DSM can be accomplished using a device which detects the speed of passing vehicles and displays this information on an electronic sign. Devices used to detect speed include video cameras and loop detectors, but radar detection is most commonly used. Information displayed on the electronic signs can be limited to just the speed of the passing vehicle or can be a message such as “REDUCE SPEED.” The sign location can also vary from overhead signs to roadside signs.

Rural roads in the United States have seen an increase in traffic as the rural population has increased. Approximately 60 million people or 21 percent of the population, live in rural communities, an increase of 11 percent since 1990. In addition, travel on rural roads by all vehicles increased by 27 percent between 1990 and 2002. The traffic fatality rate on non-Interstate rural roads in 2003 was 2.72 deaths per 100 million vehicle miles traveled (VMTs), compared to 0.99 deaths per 100 million VMTs on all other roads. Federal highway funding is not always available to improve rural roads, most of which are the responsibility of local governments with limited funds.

Driver expectation is a qualitative measure of motorists' anticipation that the roadway segment ahead will not be substantially different to similar previously encountered roadway segments. Some facilities, such as interstate facilities, are usually designed to meet driver expectations such that motorists can travel above the speed limit and still navigate the roadway safely. However on other roadway facilities, such as rural interchange ramps, driver expectancy may be violated and driving above advisory speeds can be dangerous. In general, violations of driver expectancy produce driver errors, driver discomfort, and are often crash prone locations.

1.3 Study Rationale

Dynamic Speed Monitoring (DSM) represents one promising technology that can be used to reduce speed and increase speed limit compliance. Rural roads and interchanges do not always meet driver expectations and these locations are often prone to crashes. Funding is not always readily available to local governments for traditional higher cost road improvements (e.g. roadway realignment) and lower cost alternatives are increasingly being sought after.

The objective of this thesis was to test the effectiveness of a DSM system at reducing vehicle speeds at the rural US 27/ US 192 trumpet interchange in Polk County, Florida. The system tested was a solar powered, radar based, wireless speed warning system which potentially could be used at traffic locations where it is difficult to secure power and to extended wires. The Measures of Effectiveness (MOEs) for the system were the reduction in mean and variance of speed along with the proportion of vehicles in the higher speed ranges after system implementation.

2 LITERATURE REVIEW

In order to analyze the effectiveness of the Dynamic Speed Monitoring system one needs to have an appreciation of the need for such a system as well as knowledge of similar past analysis studies. In addition, an understanding of the theory behind the DSM system components and system deployment is required. This literature review is divided into the following sections.

1. Previous studies
2. Growing Traffic on Rural Roads
3. Geometric Design Criteria
4. DSM System Components
5. DSM System Deployment

2.1 Previous Studies

2.1.1 Dynamic Speed Monitoring Studies

The effectiveness of Dynamic Speed Monitoring (DSM) Systems, sometimes called Speed Monitoring Displays (SMDs), have been studied in many papers published in the *Transportation Research Board.* Much of this research has been focused in the areas of work zone management and rural road applications.

Pesti et al (2001) evaluated the long term effectiveness of SMDs in reducing speeds and increasing speed limit compliance along an approximately 2.7 mile long term work zone section on eastbound I-80 near Lincoln, Nebraska. Three SMDs, of the portable self contained variety, were deployed as part of the study with approaching vehicle speeds displayed on 24-inch LED numerals. Maintenance of Traffic (MOT) signs were installed on each side of the roadway approaching the workzone and included SPEED LIMIT 55 signs with FINES DOUBLED sign plate, LEFT LANE CLOSED AHEAD signs, and RIGHT LANE CLOSED ½ MILE signs. A speed profile was conducted to determine higher speed locations along the roadway and to best locate the SMDs. Traffic speeds were measured four days before deployment, five times during the five week deployment, and one week after removal of the SMDs. The mean, 85^{th} percentile, standard deviation of vehicle speed, the percentage of vehicles complying with the 55-mph speed limit and the 60 and 65-mph speed thresholds were used as measures of effectiveness (MOEs) for "before" and "after" the SMDs installation. The SMDs were found to be effective in lowering speeds, increasing the uniformity of speeds, and increasing speed-limit compliance over the five-week period. The research found that after the implementation of the SMDs, there were statistically significant (α = 0.05) speed reductions in speed parameters (i.e. mean, 85^{th} percentile, and standard deviation); reduction of 3 to 4 mph for mean speed, 2 to 7 mph for 85^{th} percentile speed, and a 20 to 40 percent increase in the percentage of vehicles complying with the 55 mph and 60 mph speed thresholds. Reduction in standard deviation was not significant at all the SMDs locations. The combined long term effectiveness of the SMDs reduced to approximately 3 mph for mean speed, 3 mph for 85^{th} percentile speed, and a 10 to 20 percent increase in the percentage of vehicles complying with the 55 mph and 60 mph speed thresholds. After the SMDs were removed mean, 85^{th} percentile speed increased and speed limit compliance decreased although these values did not reach the levels observed before deployment and this suggested some residual effects of the SMDs.

In a related project, Pesti et al (2002), evaluated the effectiveness of SMDs in controlling the speed of on-ramp traffic at the rural interchange of I-80 and I-180 and the rural interchange of I-80 and US Highway 77. Similar equipment was used as in the Pesti et al (2001) study previously discussed .The mean, 85th percentile and standard deviation of vehicle speeds, the percentage of vehicles complying with the 55-mph speed limit and the 60 and 65-mph speed thresholds were used as measures of effectiveness (MOEs). The SMDs were found to be effective in lowering speeds, increasing the uniformity of speeds, and increasing speed-limit compliance during the first week of operation. After two weeks of continuous operation, the SMDs began to loose their effectiveness. The research cited two possible contributing causes, pending further investigation; relatively high percentage of commuting traffic on the ramps and driver perception that speed enforcement is less likely on entry-ramps.

Ullman et al, (2005), analyzed the effectiveness of Dynamic Speed Display Signs (DSDS) installed in seven permanent locations; a school speed zone, two advanced warning areas for school zones, two signalized intersections on high-speed roadways, and two approaches to sharp horizontal curves. Data was collected before the DSDS installation, one week after installation and again four months after installation. The average speed, 85th percentile speeds and the percent of sample exceeding the speed limit were used as measures of effectiveness. Least square regression analyses were performed between the speed of a vehicle upstream of the DSDS and that vehicle's speed measured again at the DSDS. At the school zone site and one of the signalized intersection approaches, statistically significant reductions in speeds were detected immediately after installation of the DSDS and this was maintained through the long term condition. There was a small drop in speeds at the other sites which was not maintained through the long term condition but were still slightly lower than the before condition. The research also noted that at the horizontal curves there were small decreases in the speeds of passenger vehicles but speeds for trucks were unchanged. The regression analysis determined that vehicles approaching the site at higher speeds appear to slow down more upon reaching the DSDS location than vehicles approaching at lower speeds.

Monsere et al, (2005) evaluated a dynamic curve warning system deployed on both the northbound and southbound directions of a dangerous curve on Interstate-5 in Oregon. The speeds of approaching vehicles were determined by radar and cautionary text was displayed on the electronic display panels. The five messages displayed were; “CAUTION,” “SLOW DOWN,” “SHARP CURVES AHEAD,” “YOUR SPEED IS XX MPH” and “YOUR SPEED IS OVER 70 MPH.” The measures of effectiveness were the change in mean speed for passenger cars and commercial vehicles, the change in the speed distribution for both passenger cars and trucks, and the public response to the signs. The results show a general speed reduction for both passenger cars and trucks after passing the signs. In the northbound direction there were average speed reductions of 3.3 mph for passenger cars and 3.0 mph for commercial vehicles. In the southbound direction there were average speed reductions of 2.6 mph and 1.9 mph. The speed distribution analysis indicated that there were fewer vehicles traveling in higher speed brackets for passenger vehicles and less variation in the speed of commercial vehicles. The motorist survey revealed a positive reaction to the signs with 95% of the driver noticing the signs and 84% thinking the signs aided in the navigation of the curves.

Lyles et al (2004) conducted a survey to determine crash-involved and typical driver stated responses to curves and curve-related traffic control devices (TCDs). The research involved a survey of drivers in North Carolina and Michigan and focused on rural two-lane, two-way roads. The document sent out was a six-page, 23 question survey which included an introduction to the research project, statements regarding anonymity of responses, definition of warning and regulatory signs, and pictures of each. There were 1596 surveys sent to random samples of typical drivers and 1449 surveys sent to crash-involved drivers. Of these, 206 (12.9%) typical drivers and 180 (12.4%) crash-involved drivers responded. There were six categories of questions asked and these included; questions on the adequacy of curve-related signs, response to advisory speed signs, problem curves and familiarity, contributing characteristics – driver and environment, and contribution characteristics – the curve itself. Over all, questions on adequacy of curve-related signs indicated that respondents perceived basic TCDs to be useful in anticipating and navigating horizontal curves. Questions on the response to advisory speed signs indicated that many participants drove faster than the speed limit. Question on problem curves and familiarity indicated that participants use curve signs as guidance when navigating unfamiliar curves but disregard them for familiar curves. Poor weather/pavement conditions and exceeding the speed limit were cited as the main reasons for how the driver and environment contributed to bad experiences on curves. Question about the curve characteristics that contributed to bad experiences on curves indicated that "very sharp" curves caused the most problems. The report suggested that signs on curves that are well known to drivers, be made more compelling.

In 2006, Dos Santos C., used the UCF driving simulator to test the reactions of drivers to various Variable Speed Limit (VSL) and Variable Message Sign (VMS) scenarios. These scenarios were developed based upon the successful implementation strategy that was observed using microscopic traffic simulation. These microscopic traffic simulations scenarios were derived form the real-time crash likely hood that was calculated based on split models for predicting multi-vehicle crashes during high-speed and low-speed operating conditions on freeways. The driving simulator simulated a five mile freeway section in which there were four (4) VMS, three (3) VSL, and two (2) traffic conditions (congested/ uncongested). There were a total of 24 scenarios that tested different displayed messages, abrupt and gradual changes, and congestion and no congestion. There were 90 test drivers who took part in the test and were divided into 5 different age and 2 gender groups. The study concluded that drivers are more afraid of police enforcement than risking their lives in a crash and abrupt and gradual changes in speed limits have the same effect. In addition, it was seen that females and older drivers follow better the posted speed limit/ VSL, even though, all the drivers in general reduced/increased their speed after every VSL and VMS.

Stuster and Coffman (1998) reviewed safety research related to safety and safety management and highlighted, among other things, the relationship between speed and safety. Vehicle speeds could be related to traffic safety in two ways; the greater a vehicle's velocity the less the reaction time to a potential accident, and the higher the speed the larger the kinetic energy available for dissemination during a collision. Based on the review conducted of studies such as Garber and Gadiraju (1988)[8], the report indicated that speed variance is more likely the cause of the majority of accidents as opposed to just simply higher speeds. However, it was noted that higher speeds contribute to the severity of crashes and speed management approaches should not ignore the injury consequences of vehicle speed. It was noted in the report that a 1 mph increase in speed could potentially lead to a 5% increase in crashes. In addition, the report also indicated that on rural roads the predominant crash type is vehicle off tracking (running off of road).

2.1.2 Rainfall Study

Baigorria et al (2007) conducted a study to understand the spatial variability of daily and monthly rainfall in the southeast United States (Alabama Georgia and Florida). Rainfall data was obtained from 1048 weather stations (National Climate Data Center) having rainfall data covering the period 1915 to 2004, however only 523 were selected after a preliminary screening process. The 1915 to 2004 period was divided into seven 15 year periods, however significant shifts were found between the different periods indicating that climate was not stationary in time. To avoid the effects of climate shifts detected in time, only the period 1990 to 2004 was used. For this period, only 208 weather stations were available. The southeast region has some of the warmest conditions in the USA. During most of fall and winter, rainfall occurs mainly by fronts coming from the northwestern USA and crossing the region (Frontal rainy season). During most of spring and summer, rainfall occurs mainly by convective processes and tropical storms (convective rainy season). All 208 stations in Florida were correlated with one centrally located station. For the latter, Mountain Lake in Polk County, Florida (28-56 N latitude, 81-36 W longitude and 128 feet altitude) was selected. Correlation, covariance and variance were determined on a monthly basis using daily rainfall amounts and frequencies.

At short distances (0-50 Km/ 0-28 miles), covariance of rainfall amounts between Mountain Lake and other stations were similar during the October to March frontal rainy season (range from 0.626 to 0.671) and during the April to September convective rainy season (range from 0.376 to 0.594) but were higher during March and September, which are the transition months between the frontal rainy season and the convective rainy season. Correlation of rainfall amounts decreased with distance and variance increased with distance. Of relevance to this study, correlation of rainfall amounts during May, June and July was low (0.473, 0.383 and 0.368 respectively).

At short distances (0-50 Km/ 0-28 miles), covariance of rainfall events between Mountain Lake and other stations followed similar trends as with rainfall amounts. Correlation values during the October to March frontal rainy season range from 0.723 to 0.802 and during the April to September convective rainy season range from 0.402 to 0.615 but were higher during March and September. Of relevance to this study, correlation of rainfall amounts during May, June and July was moderate (0.635, 0.640 and 0.515 respectively).

2.2 Growing Traffic on Rural Roads

The United States Census Bureau defines a rural area as an area having a population of 50,000 or less and a population density generally less than 1,000 people per square mile. In 2005, The Roadway Information Program (TRIP) evaluated the condition, use and safety of the nation's non-Interstate rural roads, based partly on an analysis of all fatal rural traffic accidents over the five year period from 1999 to 2003.

Increase in Rural Road Travel

In the twelve year period between 1990 and 2002 there was an approximately 30 percent increase in travel on rural roads. This can be attributed to an increase in rural area population which increased by 11% since 1990 to 60 million people. It was noted that the increase in rural population was fueled by higher levels of natural amenities, the retirement of the Baby Boom generation, affordable housing, and small town quality of life within commuting distance to larger metropolitan areas.

Truck Reliant Food Distribution System

In the ten year period between 1990 and 2000, the percentage of U.S. grains, such as corn, wheat and soybeans, delivered by truck increased from 36 percent to 50 percent. The United States Department of Agriculture reported that 90 percent of refrigerated perishables, such as fruits and vegetables, are delivered by truck. Livestock and other animals are almost exclusively delivered by truck also. In general food production mostly occurs in rural areas while food consumption is concentrated in urban areas.

Traffic Fatalities Rate Higher on Rural Roads

The fatality rate on rural, non-Interstate roads increased from 2.65 fatalities per 100 million vehicle miles traveled in 2000 to 2.72 in 2003. The traffic fatality rate of 2.723 deaths for every 100 million vehicles miles traveled on non-Interstate rural roads in 2003, compared to a fatality rate of 0.99 deaths per 100 million vehicles miles traveled on all other roads. Florida is listed as one of the five states with the largest number of rural non-Interstate traffic deaths from 1999 to 2003. The reduction of the fatality rate on rural non-Interstate routes has lagged behind the safety improvements on all other routes since 1990. Between 1990 and 2003 the fatality rate on all other roads decreased by 32 percent but on rural non-Interstate road there was only a decline of 21 percent.

Fatalities on Rural Roads are More Likely When Off-tracking Occurs

Fatal non-Interstate rural accidents are more likely than fatal accidents on all other routes to occur once a vehicle has left the roadway. For all fatal accidents occurring between 1999 and 2003, 47 percent on rural non-Interstate and 35 percent on all other routes involved a vehicle leaving the roadway. Drivers were approximately 6.5 times more likely to be killed while attempting to negotiate a curve on a rural, non-Interstate route than on all other roads.

Most Speed Related Fatalities Occur on Rural Roads

From 2000 through 2002, about 62 percent of the nation’s speeding related fatalities were on rural roads. This amounted to about 24,000 of the 39,000 fatalities where speed was a contributing factor. Speed influences crashes; by increasing the distance traveled from when a driver detects an emergency until the driver reacts, increasing the distance needed to stop, increasing the severity of an accident (i.e., when speed increases from 40 to 60 miles per hour, the energy released in a crash more than doubles), and reduces the ability of the vehicles, restraint systems, and roadside hardware, such as guardrails and barriers, to protect occupants.

Difficulties in Improving Safety on Rural Roads

Many rural roads are low volume roads and this makes it difficult to justify paying the high cost of improvements. Many rural roads are local county roads and federal funds cannot be used to pay for improvements. In addition, many rural accidents occur at locations far removed from emergency care facilities and this increases the danger when a crash does occur.

2.3 Geometric Design Criteria for Interchange Ramps

A "ramp" is the sloping surface that connects two different grade roadways at an interchange. There are numerous possible ramp combinations which are dictated by such factors as demand volumes, topography, land availability, and cost. Ramp design is possibly the most important aspect of interchange roadway design as they facilitate the safe transition of vehicles from a high speed roadway to a lower speed roadway or vice versa. In cases where roadways of the same speed are connected, ramps allow for the continuous flow required to maintain these speeds.

Design Speed

The design speed on ramps is related to the design speeds of the intersecting roadways. The driver usually anticipates some speed reduction when turning off a highway. The AASHTO, "Greenbook," 2001 provides preferable ramp design speed as shown in Table 2-1, with the highway with the greater design speed being the control for ramp design speed selection. It should be noted that upper range values given in the table are not always practical because of insufficient land available for the large radii loops that would be required.

Table 2-1: Guide Values for Ramp Design Speed as Related to Highway Design Speed

US Customary										
Highway design speed (mph)	30	35	40	45	50	55	60	65	70	75
Ramp design speed (mph)										
Upper range (85%)	25	30	35	40	45	48	50	55	60	65
Middle range (70%)	20	25	30	33	35	40	45	45	50	55
Lower range (50%)	15	18	20	23	25	28	30	30	35	40
Corresponding minimum radius (ft)	see Exhibit 3-43									

**Reproduced from AASHTO, "Greenbook," 2001, Ex.10-56*

Sight distance

Ramps should have a sight distance at least as great as the safe stopping sight distance (SSD). Passing sight distance is not always required, however at minimum, there should be a clear view of the entire exit terminal, including the exit nose and a section of ramp roadway beyond the gore.

Horizontal Curvature

The design considerations of regular horizontal curves are also applicable to ramp design. Simple curves are used in ramp design, with spiral and compound curves being more desirable to meet site conditions and to follow the natural path of vehicles. It should be noted that when the design speed of a roadway is 45 mph or greater the use of a compound curve is often impractical since a large amount of right-of-way is needed. Typically a single lane ramp lane is designed to be 15 feet wide and allows drivers of smaller vehicles to select their own spiral curve even though a spiral or compound curve is not used.

A simple curve has a constant radius to achieve the desired deflection without the use of an entering or exiting transition. Because of their simplicity and ease of design, survey and construction, simple curves are the most frequently used type of curve. In Table 2-2, the FDOT, *"Florida Greenbook"* – 2005, suggests the following minimum radius for simple curves.

Table 2-2: Minimum Radii of Simple Curves

RURAL Based on e_{MAX} = 0.10			URBAN High-Speed Highways and Streets Based on e_{MAX} = 0.05		
Design Speed (MPH)	Max. Degree of Curvature	Min. Radius (FEET)	Design Speed (MPH)	Max. Degree of Curvature	Min. Radius (FEET)
15	104° 45'	55	---	---	---
20	57° 45'	100	---	---	---
25	36° 15'	160	---	---	---
30	24° 45'	230	30	20° 00'	285
35	17° 45'	320	35	14° 15'	400
40	13° 15'	430	40	10° 45'	535
45	10° 15'	555	45	8° 15'	695
50	8° 15'	695	50	6° 30'	880
55	6° 30'	880	55	5° 00'	1125
60	5° 15'	1095	---	---	---
65	4° 15'	1345	---	---	---
70	3° 30'	1640	---	---	---

**Source: Reproduced from FDOT, "Florida Greenbook," 2005, Table 3-3*

Compound curves consist of two or more adjacent curves without a tangent section intervening between them. They offer transition curvature for the vehicle path, but the change in curvature can mislead the driver. To provide smooth transitioning from the flat curve to a sharp curve, and to facilitate reasonable deceleration rate on a series of curves of decreasing radii, AASHTO suggests minimum and desirable lengths for a compound curve when followed by a curve of one-half radius or preceded by a curve of double radius (shown in Table 2-3). These are based on a deceleration of 3 mph/s, and a desirable minimum deceleration of 2 mph/s.

Table 2-3: **Length of Circular Arc for a Compound Intersection Curve**

Metric			US Customary		
	Length of circular arc (m)			Length of circular arc (ft)	
Radius (m)	Minimum	Desirable	Radius (ft)	Minimum	Desirable
30	12	20	100	40	60
50	15	20	150	50	70
60	20	30	200	60	90
75	25	35	250	80	120
100	30	45	300	100	140
125	35	55	400	120	180
150 or more	45	60	500 or more	140	200

**Reproduced from AASHTO, "Greenbook," 2001, Ex.3-46*

In addition, AASHTO provides the following guidelines:

1. Compound curves can be used for intersection curb radii, ramps, and loops, but should be avoided on mainlines.
2. For compound curves at interchanges, it is desirable that the ratio of the flatter curve to the sharper curve should not exceed 1.75:1.

Some states, such as Minnesota (MnDOT, *"Road Design Manual -2004,"*), also recommend that a 3-centered compound curve be used with the center curve being the minimum radius. Furthermore, the arrangement could be symmetrical or asymmetrical as may be appropriate for any variance in design speed between the two intersecting highways. The length of the flatter transition curve should allow for a desirable acceleration/deceleration rate of 2 mph/sec, and a minimum rate of 3 mph/sec.

Spiral curves, when designed properly, can provide the ideal vehicular transition into a circular curve. Spiral curves are also advantageous because they fit the transition length needed to develop the full design superelevation without the need to develop any transition on the adjacent tangent sections (Garber and Hoel, 1998). With the continuous advance of technology, spiral curves are becoming easier to design, survey, and construct; however, due to their complexity, their use should be limited to highways with design speeds of over (50 mph) and on curves with radii less than 580 feet (degrees of curve greater than 3 degrees). AASHTO suggests minimum lengths and maximum radii for spiral curves, as shown in Table 2-4 and Table 2-5.

Table 2-4: **Minimum Lengths of Spiral for Intersection Curves**

	Metric						US Customary						
Design speed	(km/h)	30	40	50	60	70	(mph)	20	25	30	35	40	45
Minimum radius	(m)	25	50	80	125	160	(ft)	90	150	230	310	430	550
Assumed C	(m/s^3)	1.2	1.1	1.0	0.9	0.8	(ft/s^3)	4.0	3.75	3.5	3.25	3.0	2.75
Calculated length of spiral	(m)	19	25	33	41	57	(ft)	70	87	105	134	156	190
Suggested minimum length of spiral	(m)	20	25	35	45	60	(ft)	70	90	110	130	160	200

**Reproduced from AASHTO, "Greenbook," 2001, Ex. 3-45*

Table 2-5: Maximum Radii of Spiral for Intersection Curves

Metric		US Customary	
Design speed (km/h)	Maximum radius (m)	Design speed (mph)	Maximum radius (ft)
20	24	15	114
30	54	20	203
40	95	25	317
50	148	30	456
60	213	35	620
70	290	40	810
80	379	45	1025
90	480	50	1265
100	592	55	1531
110	716	60	1822
120	852	65	2138
130	1000	70	2479
		75	2846
		80	3238
Note: The safety benefits of spiral curve transitions are likely to be negligible for larger radii.			

**Reproduced from AASHTO, "Greenbook," 2001, Ex. 3-33*

Super elevation

The maximum rates of super elevation used on highways are controlled by four factors:

1. Climate conditions (i.e., frequency and amount of snow and ice)
2. Terrain conditions (i.e., flat, rolling, or mountainous)
3. Type of area (i.e., rural or urban)
4. Frequency of very slow moving vehicles whose operation might be affected by high super elevation rates

The Florida Department of Transportation (FDOT), *Plans Preparation Manual, Volume 1* - 2005 Edition," recommends using a maximum super elevation of 10% on ramp curves.

2.4 DSM Equipment Information

An understanding of the components, configurations and mechanics of the DSM system was required in order to successfully install and test the system. The following section briefly describes each component and illustrates how the system works.

System Components

The main components of the DSM system were; the radar, the speed display sign, the radio communicators, the solar panels, the twelve-volt batteries, and the charge controllers. These were over the shelf components that were wired together to function together as the DSM system

The radar used was a System Interface-3 (SI-3) Configurable Speed Sensor. This radar was used because the internal firmware is customizable and allowed for changes to the range and output format. Features include K-band antenna (portion of the electromagnetic spectrum in the microwave range of frequencies between 12 to 63 GHz), directional, RS232 serial port, 5 to 150 mph speed range and 1,500 feet (default) to 3,000 feet range. The radar bounces microwave radiation off of approaching vehicles and detects the reflected waves. These waves are shifted in frequency by the Doppler Effectf (change in frequency of waves as the vehicle moves relative to the radar), and the difference in frequency between the directed and reflected waves provides a measure of the vehicle speed.

The two radios units used were the XTend-PKG-R™ RS-232/485 Radio Frequency modem. One modem is used to send speed information from the radar and the other is used to receive speed information at the sign. The radio has a wide range of up to 40 miles and operates at an ISM frequency (radio frequency and electromagnetic fields used for industrial, scientific, and medical purposes other than communications) of 900 MHz. The radio operates with 256-bit AES (Advanced Encryption Standard) encryption which encrypts the speed information while it is sent between radios and helps prevent another unauthorized radio from reading the data. The radio is designed to operate at temperatures between -40 to 175 ^{0}F.

The speed display sign used was an OnSite 50 (OS 50) which is compatible with the SI-3 radar. The OS 50 has two 18-inch LED digit displays, visible from a 1000 feet, which display the speed of passing vehicles and can be set to flash if motorists violate a preset speed. The speed sign has the added benefit of being compatible with the EZ –Stat Traffic Data Logger which is a small serial port device which can be plugged into the sign to record speeds.

The solar panels used were the British Petroleum 3125u (BP 3125u) 125W Solar Panel. One module is used to charge the radar battery supply and two modules are used to charge the speed sign battery supply. Each module is approximately 60 inches by 27 inches and comprises 36 Silicon Nitride efficiency cells. The panel has a maximum voltage of 125 W and typically operates at 15 percent efficiency.

The UB UB30H Sealed Lead Acid Battery was used. The battery has a cycle use voltage range of (13.5V-13.8V) and a stable range of (13.8V-14.0V), with a maximum current of 30A. The equipment consists of eight (8) batteries. Two (2) were used for supplying the radar system and six (6) were used for supplying the speed warning sign system.

The charge controllers used for the system were Prostar 30 (PS-30) solar controllers. These controllers are used to regulate the power flowing from a photovoltaic panel into a rechargeable battery. The controller employs Pulse Width Modulation (PWM) which is used to achieve constant battery by tapering the current from the solar array according to the battery's conditions and recharging needs. This leads to more efficient charging and a longer battery life. The charge controller also electronically protects against solar and load short circuits and over load and lightening surges.

System Setup

A typical DSM system function flow is illustrated in Figure 2-1. There are four (4) main interactions that occur. In process one (1), radar waves from the SI-3 radar strike the approaching vehicles and based upon the Doppler effect, speed is determined. In process two (2), the XTend-PKG-RS-232.485 RF radio, connected to the radar, sends the AES encrypted speed information to a second XTend-PKG-R™ RS-232/485 RF radio connected to the speed sign. In process three (3), the OnSite-50 speed sign displays the speed of the passing vehicle via the 18-inch LEDs and this is visible to the driver. Process four (4), is an ongoing process in which the BP 3125u solar panels absorb solar radiation which is used to charge the 12-volt batteries, as regulated by the PS-30 charge controllers.

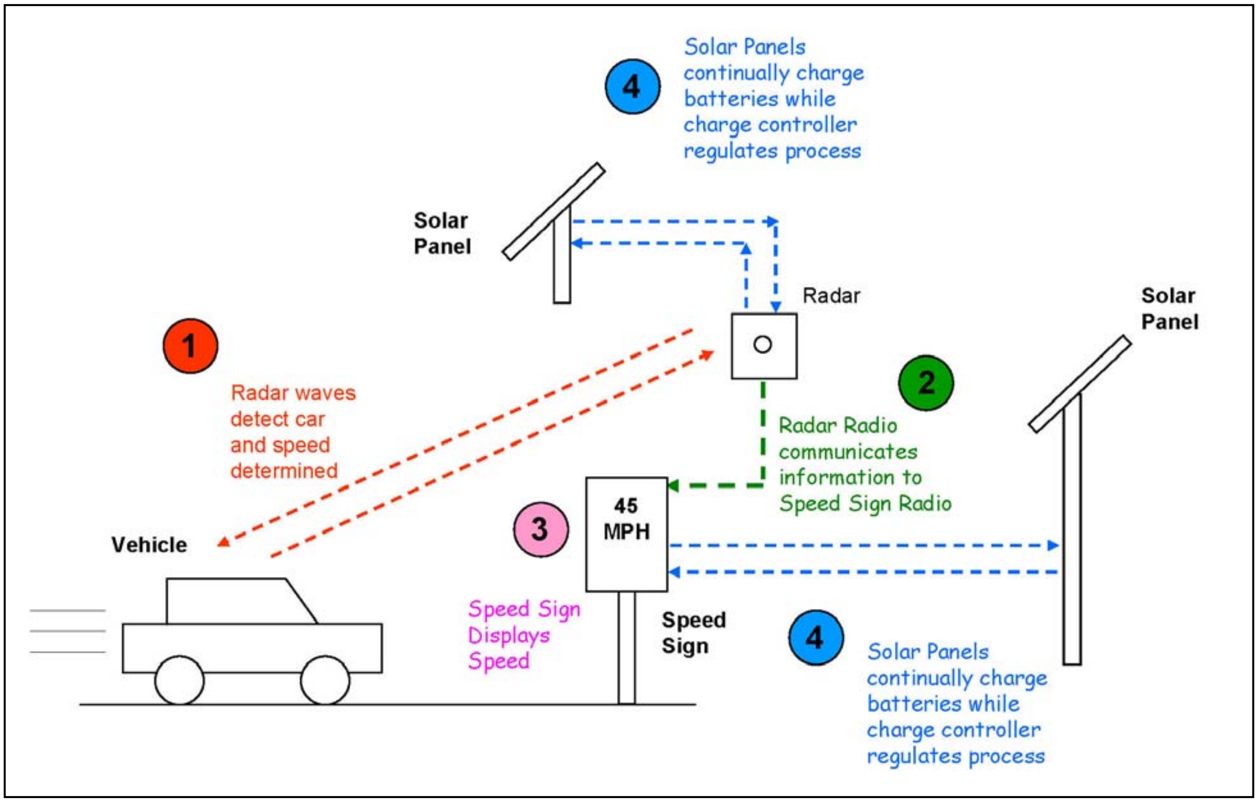


Figure 2-1: Schematic Diagram of DSM System

2.5 DSM System Installation

The FHWA, "*Manual of Uniform Traffic Control Devices (MUTCD) – 2003 Edition*," states that the primary purpose of traffic control devices is to promote safety and efficiency on all streets and networks. To be effective, a traffic control device should fulfill five basic requirements:

1. Fulfill a need;
2. Command attention;
3. Convey a clear, simple meaning;
4. Command respect from road users; and
5. Give adequate time for proper response.

The placement of a traffic control device should be within the road user's view so that adequate visibility is provided. To aid in conveying the proper meaning, the traffic control device should be appropriately positioned with respect to the location, object, or situation to which it applies. The location and legibility of the traffic control device should be such that a road user has adequate time to make the proper response in both day and night conditions.

One type of traffic control device is a traffic sign and these can be regulatory, warning or guidance signs. Regulatory signs inform road users of a specific traffic law or regulation and indicate the requirement of the road user. Examples of Regulatory signs include; stop signs, speed limit signs, and turn prohibition signs. Warning signs alert road users to unexpected conditions along the roadway that might not be readily apparent. Examples of Warning signs include advisory speed signs, speed hump signs, and winding road signs. Guidance signs present information to road users which aid in their journey. Examples of Guidance signs include street/route name signs, parking area sign, and scenic area signs.

The design and placement of signs for higher volume roadways is generally approached on the premise that the signing is primarily for the benefit and direction of road users who are not familiar with the route or area.

Design of Signs

The components of sign design include size, shape, color, composition, lighting or retro reflection, and contrast. These components are critical in developing signs that are legible, uniform, and command the attention and respect of the commuting public. The minimum size of sign recommended for rectangular advisory speed signs is 26 inches by 36 inches (MUTCD - 2003 Edition, Table 2C-2).

Placement of Signs

Signs should generally be placed in such a manner so that the five basic requirements of traffic control devices, previously discussed, are met. In generally, and where practically attainable, signs should be located on the right hand side and should be spaced sufficiently far apart along the road so that the appropriate decisions can be made.

The lateral offset and height for a single column sign located behind a guardrail is given by the FDOT, 2005, *"Design Standards" – Index No. 17302, Case VI.* This is illustrated in Figure 2-2.

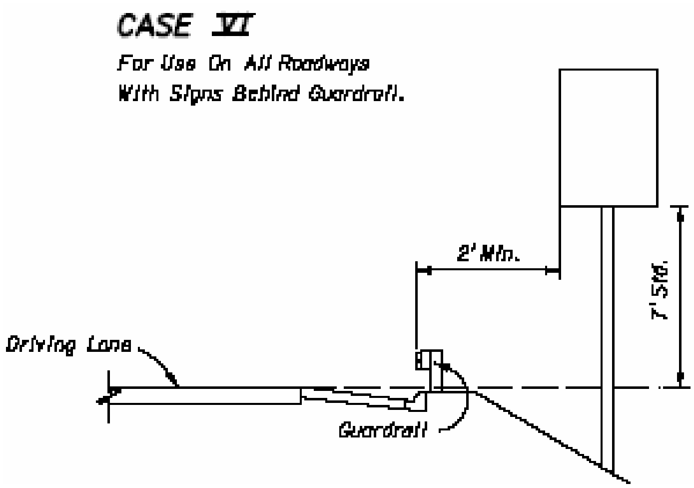


Figure 2-2: Typical Section for a Single Column Sign behind a Guardrail

The MUTCD – 2003 Edition, Table 2C-4 (see Table 2-6) recommends the minimum distance for the advanced placement of warning signs. Signs are to be placed to allow sufficient time Perception, Identification (understanding), Emotion (decision making), and Volition (execution of decision) called the PIEV time.

Table 2-6: Guidelines for Advanced Placement of Warning Signs

Posted or 85th-Percentile Speed	Advance Placement Distance [1]								
	Condition A: Speed reduction and lane changing in heavy traffic[2]	Condition B: Deceleration to the listed advisory speed (mph) for the condition[4]							
		0[3]	10	20	30	40	50	60	70
20 mph	225 ft	N/A[5]	N/A[5]	—	—	—	—	—	—
25 mph	325 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—
30 mph	450 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—
35 mph	550 ft	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—
40 mph	650 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—
45 mph	750 ft	175 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—
50 mph	850 ft	250 ft	200 ft	150 ft	100 ft	N/A[5]	—	—	—
55 mph	950 ft	325 ft	275 ft	225 ft	175 ft	100 ft	N/A[5]	—	—
60 mph	1100 ft	400 ft	350 ft	300 ft	250 ft	175 ft	N/A[5]	—	—
65 mph	1200 ft	475 ft	425 ft	400 ft	350 ft	275 ft	175 ft	N/A[5]	—
70 mph	1250 ft	550 ft	525 ft	500 ft	425 ft	350 ft	250 ft	150 ft	—
75 mph	1350 ft	650 ft	625 ft	600 ft	525 ft	450 ft	350 ft	250 ft	100 ft

**Reproduced from FHWA, "MUTCD," 2003 Edition, Tb. 2C-4*

3 METHODOLOGY

The westbound to southbound ramp (called the southbound entry ramp) of the US 27/ US 192 trumpet interchange in Polk County was selected as the study location because it is a historically crash prone location. This chapter describes the study location, DMS system and effectiveness analysis methodology. The measure of effectiveness (MOEs) for the system was the reduction in mean and variance in speed along with the proportion of vehicles in the higher speed ranges after system implementation.

3.1 Study Area

The US 27/ US 192 trumpet interchange is located on the border of Polk and Lake County (as well as District 1 and District 5) in Central Florida as shown in Figure 3-1.

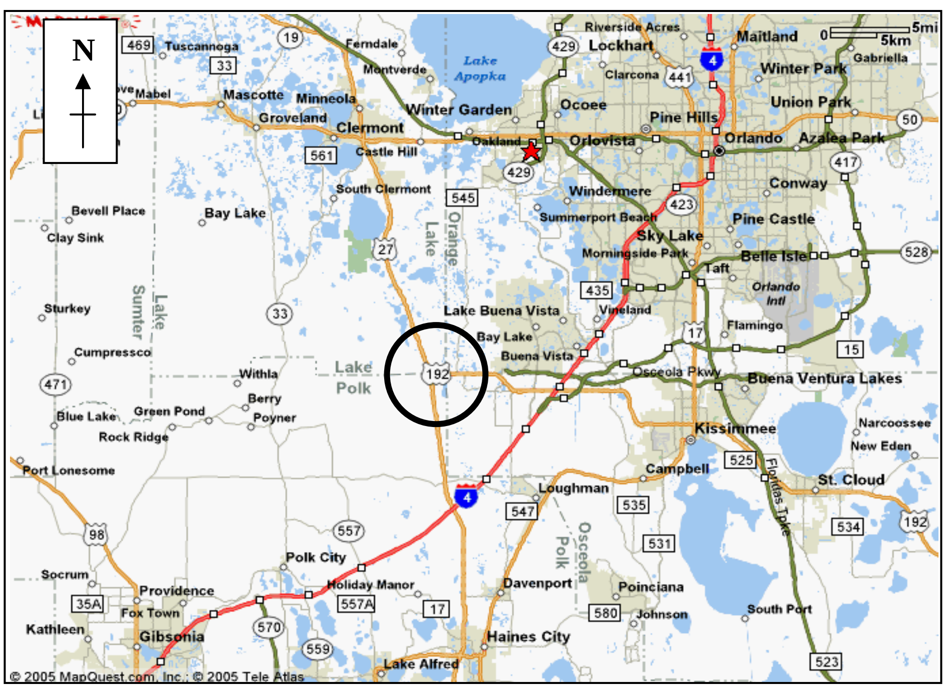
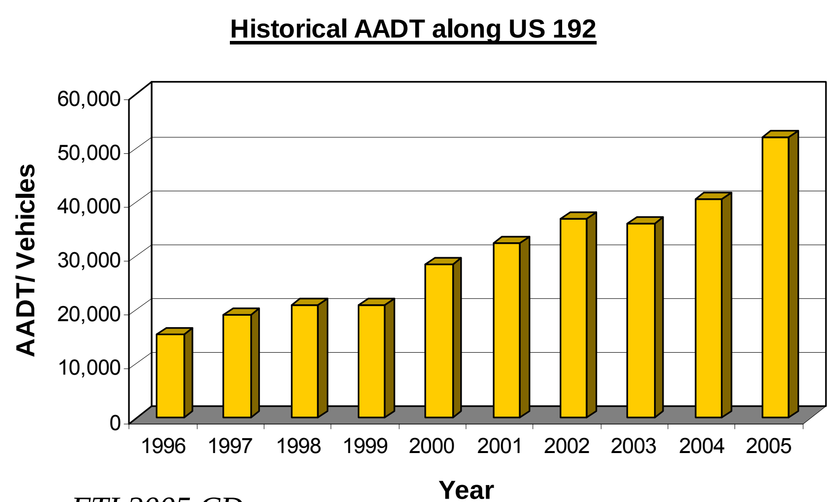


Figure 3-1: **Location map of US 27 and US 192 Interchange**

The interchange lies on unincorporated county land and is not associated with any city. US 27 runs approximately north-south through Lake and Polk County and provides an important alternative to Interstate-4. US 192 runs approximately east- west and passes major Developments of Regional Impact (DRIs) such as Walt Disney World and Celebration. Currently both US 27 and US 192 are 4 lane divided, class 2 roadways (rural principle arterials) in gently rolling terrain.

Polk and Lake County, though not as developed as Orange and Seminole counties, are rapidly developing. The home construction boom that occurred in Florida between 2003 and 2005 resulted in numerous residential developments being built along US 27. Much of the traffic associated with the interchange is also generated from the nearby Disney attractions located east of the interchange. This increased development has placed greater demand on the trumpet interchange. Figure 3-2 and Figure 3-3 illustrate historical AADT along both roadways and indicate an average growth rate of 211% between 1996 and 2005.



Source: FTI 2005 CD

Figure 3-2: Historical AADT along US 192

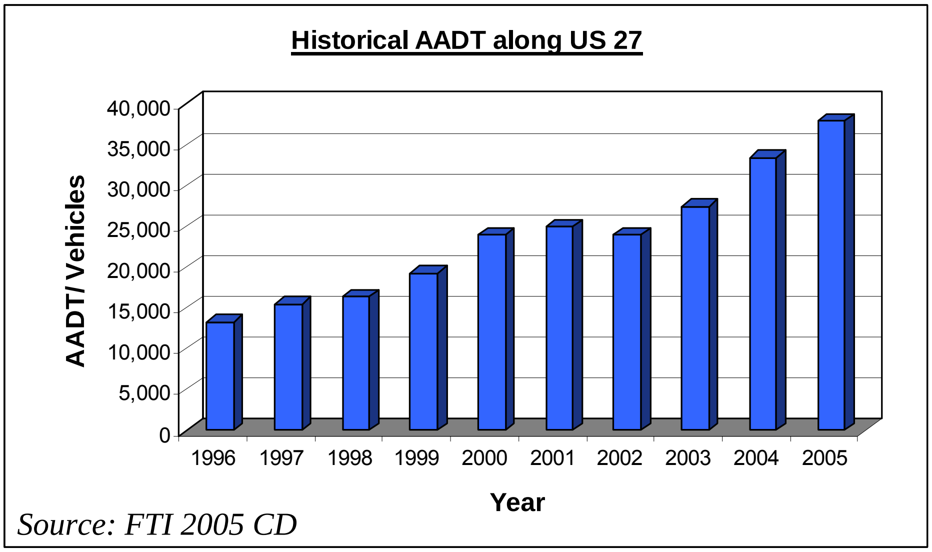


Figure 3-3: Historical AADT along US 27

3.2 Study Ramp

The US 27/ US 192 interchange southbound entry ramp (westbound to southbound movement) is a single lane ramp which has a posted advisory speed of 35 mph. An aerial view of the study ramp is shown in Figure 3-4. The speed limit on both US 27 and US 192 is 55 mph. Motorist heading west along US 192 and wishing to go south on US 27, pass under US 27 and utilize the study ramp. At present the traffic control devices that exist on the site are advisory speed (MUTCD W13-3), curve ahead (MUTCD W1-2), and Chevron Alignment (MUTCD W1-8) advisory signs. Some of these signs are shown in Figure 3-5 and Figure 3-6.

Figure 3-4: Aerial View of US 27/ US 192 Interchange Southbound Entry Ramp

Figure 3-5: US 27/ US 192 Interchange Southbound Entry Ramp and Advisory Speed Sign

Figure 3-6: Advisory Speed Sign and Curve Ahead sign

3.3 DSM System

3.3.1 System Components

The solar-based radar wireless traffic monitoring system developed for testing by UCF is essentially a solar powered, radar based DSM which eliminates the need to run wires to obtain interconnect between components of the system or to obtain electrical power. This type of system is advantageous in rural areas where obtaining electrical power would otherwise be difficult and costly.

As previously discussed in Section 2.4, the DSM system has the following six (6) main components:

1. Radar detection unit
2. Speed display sign
3. Radio communicators

4. Solar panels for changing each battery set
5. Twelve-volt battery sets for each unit
6. Charge controller for each battery unit

The radar unit detects the speeds of the approaching vehicles and sends this information using a radio modem to the speed display sign which has a radio modem which receives the information. The speed sign then displays the speed of the passing vehicle and flashes if above the speed limit (35 mph). The battery sets are used to power each unit and the solar panels are used to charge the batteries. Figure 3-7 to Figure 3-16 show pictures of the DSM system utilized for the study.

Figure 3-7: Speed Display Sign

Figure 3-8: Speed Display Sign and Solar Panel

Figure 3-9: Approach to Southbound Entry Ramp Showing both Speed Sign and Radar

Figure 3-10: Radar Unit Located on US 27 Bridge Overlooking Approaching Ramp Traffic

Figure 3-11: Radar Unit Located on US 27 Bridge Looking Up From US 192

Figure 3-12: Radio Unit Located Inside of Speed Sign and Acting as a Receiver

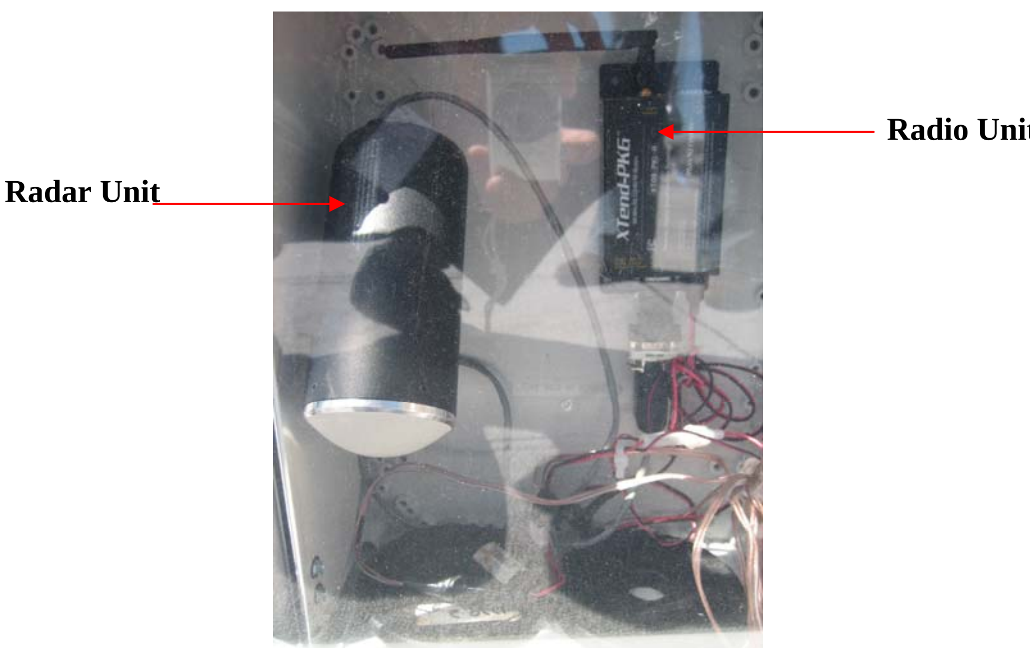


Figure 3-13: Radar and Radio Units Located Inside of Radar Box

Figure 3-14: Twelve-Volt Battery Set for Powering the Speed Display Sign

Figure 3-15: Charge Controller Used in the DSM System

Figure 3-16: Twelve-Volt Battery Set and Solar Panel for Powering the Radar Unit

3.3.2 System Component Testing

Prior to installation of the DSM system at the study site, the system was first tested at the UCF campus to ascertain the system's ability to function in the natural environment (temperature, humidity and rain). Following this, a trial field test was conducted to verify the system's ability to function as intended. This included a test of reliable radio communication, responsiveness of speed display, visibility during the day and night, and calibration of radar inclination. Figure 3-17 and Figure 3-21 provide pictures of the DSM system testing.

Figure 3-17: Testing the DSM Components on the Engineering Building Roof at UCF

Figure 3-18: Tuning Fork Used to Simulate the Frequency of a Passing Vehicle

Figure 3-19: Field Testing the Radar and Radio Unit on Site

Figure 3-20: Checking the Visibility of the Speed Sign at Night

Figure 3-21: Adjusting and Calibrating the Radar Inclination Angle

3.3.3 System Setup

Speed Sign

The FHWA, "*MUTCD,*" 2003 Edition (Table 2C-4), recommends the minimum distance for the advanced placement, height and lateral clearance of warning signs. The speed sign was off set laterally outside the roadway clear zone. The lowest point of the sign was 7 feet above the grade of the roadway. The speed sign was installed approximately 250 feet upstream from the point of curve (where the curve starts). These dimensions are shown in Figure 3-22 and Figure 3-23.

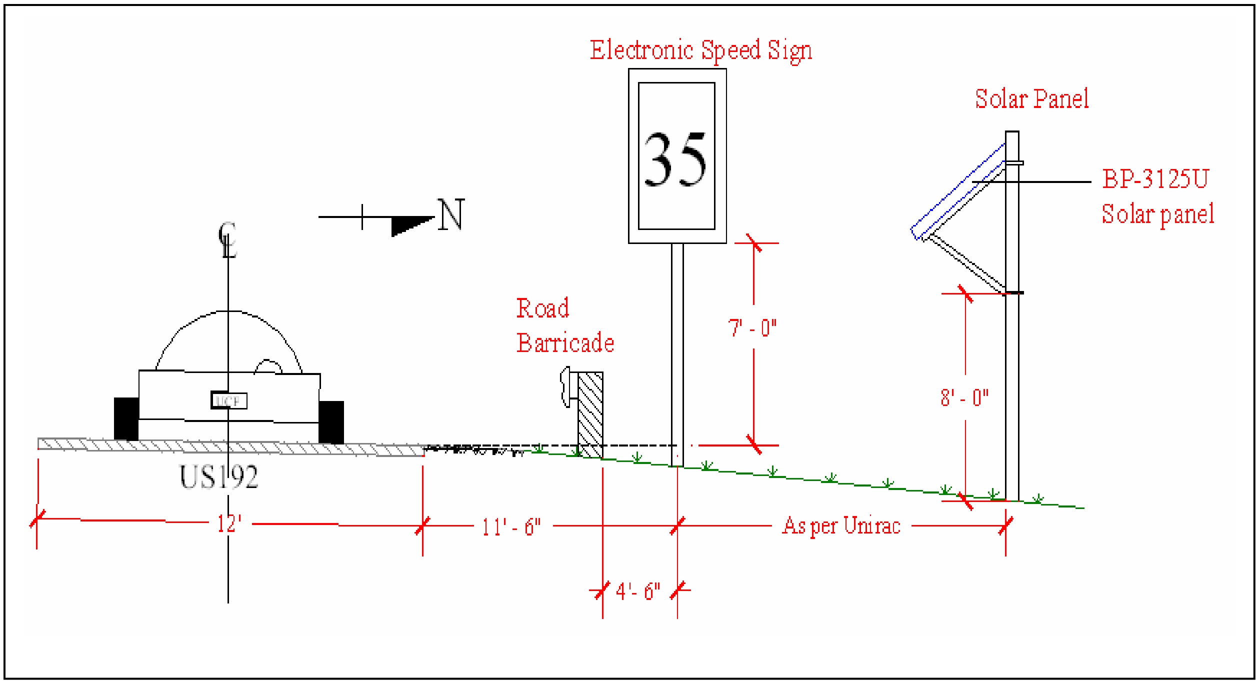


Figure 3-22: Horizontal Clearance Dimensions for Speed Sign

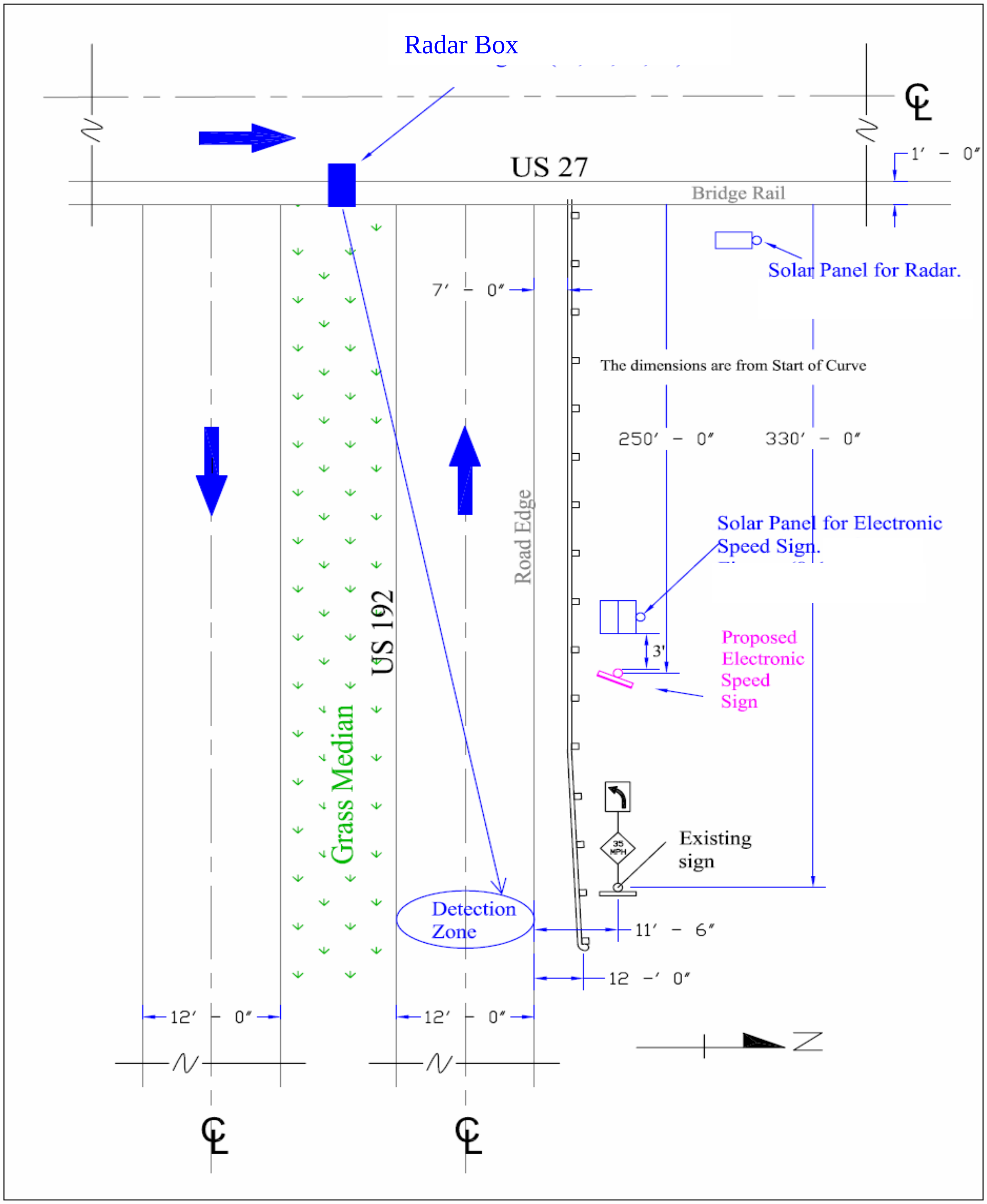


Figure 3-23: Installation Dimensions for Speed Sign

Radar Unit

The radar unit was installed on the US 27 overpass bridge above the median of US 192 as also shown in Figure 3-23. The radar unit was installed about 80” above the bridge deck. The radar and its radio were housed in a box enclosure which was connected to a pole and mounted to the outside wall of US 27 bridge. The pole was offset 1 foot from the bridge but designed in such a manner so as to allow the box enclosure to be rotated for better accessibility during maintenance.

The box enclosure had an optically clear Lexan face that allows the unhindered penetration of the radar beam. The radar detector was attached in such away so as to allow adjustment of the angle of inclination.

Battery and Solar Panels

The battery units and solar panel together formed the power supply for the radar unit and speed sign. The battery unit contained 12- volt batteries and the solar panel were used to charge these batteries. The solar panels were elevated 12 feet in the air and oriented in a south facing direction so as to allow for maximum solar absorption.

3.4 Data Collection and Analysis Procedures

3.4.1 Crash Data Analysis

Crash data for the US 27/ US 192 interchange was obtained from the Polk County Traffic Engineering Department and the Lake County Traffic Engineering Department for the years 1996 to 2004. More recent crash data was not readily available as of the writing of this thesis.

The crash data was analyzed using descriptive statistics in order to visually identify any readily apparent trends, such as potential contributing causes, in the data. The accident data for both the entire interchange and the study ramp were sorted by crashes per year, crash type, contributing cause, day occurring, severity, wet or dry and day or night and presented in the form of bar charts and pie charts.

3.4.2 Existing Geometry Analysis

Roadway design plans were obtained for the existing alignment of the study ramp which provided information such as curve radii, point of intersection (PI), point of curve (PC), point of tangent (PT), and stationing. The existing geometrical design details for the study ramp, as contained in the design plans, were compared to current FDOT and AASHTO design standards.

3.4.3 Rainfall Data Analysis

The aim of the rainfall data analysis was to verify that the Before and After daily rainfall conditions for the speed data used in the analysis were similar. This was done in order to remove any potential contribution to speed reduction due to rainfall. That is, since divers tend to drive slower when it is raining, if either the Before or After condition was more rainy than the other, then the speed reduction observed would not be representative of the effect of the DSM system.

Daily rainfall data was obtained from the Weather Underground (www.wunderground.com) website for each day that speed data was collected. Data was collected from May 20th, 2007 to July 20th, 2007 at a weather station located approximately 10 miles to the north of the study site at Southern Fields Clermont in Lake County. This was the closest active weather station to the study site. This data was used because a previous study (see Section 2.1.2) had indicated that the occurrence of a rainfall event in Polk County, Florida is moderately correlated. Figure 3-24 shows the location of the station in relation to the project study area.

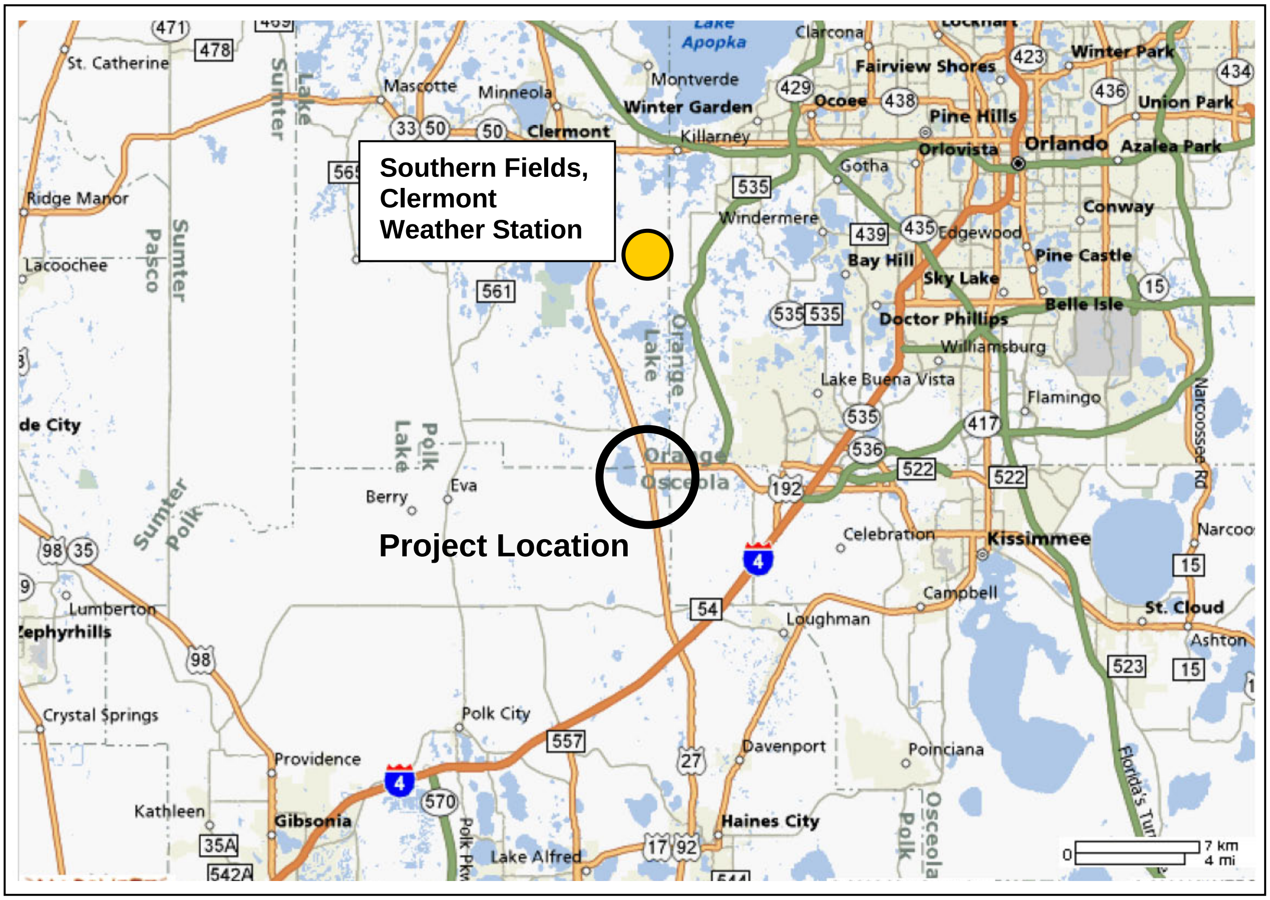


Figure 3-24: Location of Rainfall Data Collection Site

The total and average rainfall for both conditions was investigated and the rainy days of the more rainy condition identified. These days were then investigated using 10 minute daily rainfall data. This investigation identified the time period (day AM, day PM, night AM, night PM) on that rainy day in which a storm occurred and speed data corresponding to this time period was removed for the data sets. Speed data for a similar time period during a non–rainy day was then used to replace the eliminated data in order to maintain, to the extent possible, an approximately fourteen (14) day and seven (7) day Approach and PC data set, respectively, for that “more rainy condition.”

3.4.4 Speed Data Analysis

Speed data sets were collected both Before and After installation of the DSM system. Speed data was also colleted via the DSM system radar as vehicles approached the sign (termed Approach data) and speed data was collected at the point of curvature (termed PC data) of the study ramp using pneumatic tubes. Figure 3-25 shows the two speed data collection location points.

Two weeks of 24-hour Approach speed data and one week of 24-hour PC speed data, respectively, was collected both Before and After the DSM system was installed. The Before data was collected during the weeks directly before and the After data was collected during the weeks directly after installation of the DSM system. The speed data was collected between May 20th, 2007 and July 20th, 2007 which occurred towards the start of the Lake and Polk County school summer break. This was done in order to eliminate the potential for variation in the speed data due to some data being collected during the school term and some data being collected during the summer break. The following four sets of speed data were collected; Approach speed data Before installation, Approach speed data After installation, Point of curvature (PC) speed data Before installation, and Point of curvature (PC) speed data After installation.

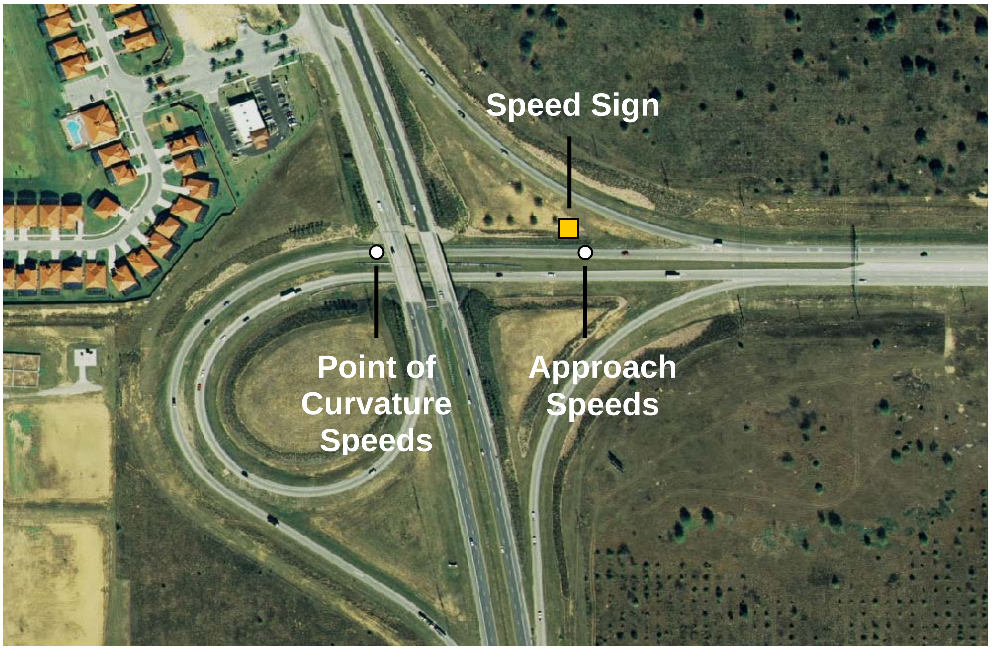


Figure 3-25: Speed Data Collection Locations

The Approach speed data was recorded in a raw format, i.e. speed of individual vehicles, and the Point of Curve data (PC data) was obtained, from the pneumatic tubes, in a grouped frequency format. For consistency, presentation purposes, similar speed range, and because almost the same vehicles are passing the two sites (due to proximity and no in between exit points), the Approach data was grouped into similar speed bins as the PC data. For both the Approach and PC data, the original combined data were compiled into eight (8) data sets; Entire data set, Day/ Night time data set, Daily data sets, Time of Day or TOD data sets, Weekdays TOD data set, Weekend TOD data set, Speed Ranges data set, and Higher Speed Ranges data sets. The Day time data set was the speed data set from 6:15 AM to 8:30 PM. And the Night time data set was the speed data from 8:30 PM to 6:15 AM. The TOD data sets were all the data sorted into the following time intervals; 12 AM to 7 AM, 7 AM to 9 AM, 9 AM to 11 AM, 11 AM to 1 PM, 1 PM to 4 PM, 4 PM to 6 PM, and 6 PM to 12 AM. The Weekday and Weekend TOD data sets were the TOD datasets for weekdays (Monday to Thursday) and Weekends (Saturday and Sunday) respectively. The Speed Ranges data set was the entire speed data sorted into speed ranges of 1 to 35 mph, 36 to 47 mph, 48 to 59 mph, and 60 to 147 mph (147 was the maximum speed that was recorded by the pneumatic tubes) . The Higher Speed Ranges data set was the data only in the greater than 57 mph speed bins for the Approach speed data and the data only in the greater than 45 mph speed bins for the PC speed data.

To determine the effectiveness of the DMS system, the speeds at the Approach and PC locations were each separately analyzed statistically. This mainly involved comparing the Before and After speeds of the eight (8) data sets. The parameters evaluated were; the mean, variance, proportion of vehicles obeying the advisory speed/ speed limit, proportion of vehicles obeying the advisory speed/ speed limit + 5 mph, proportion of vehicles obeying the advisory speed/ speed limit + 10 mph, proportion of vehicles in speed range (for Speed Range data sets only), the 85th percentile, and coefficient of variance. The mean, variance and proportion were analyzed statistically and the 85th percentile and coefficient of variance parameters was included for comparative purposes. Four (4) types of analyses were conducted; Descriptive statistics and check for Normalcy by visual inspection, Hypothesis tests for a difference in means (t-distribution), difference in variance (F-distribution), and difference in proportion (approximation to the Binomial). Descriptive statistics was used to present the data and frequency graphs visually inspected for a normal (bell shaped) distribution. A 95% significance level was used for all analysis. Figure 5-26 summarizes the speed data analysis steps.

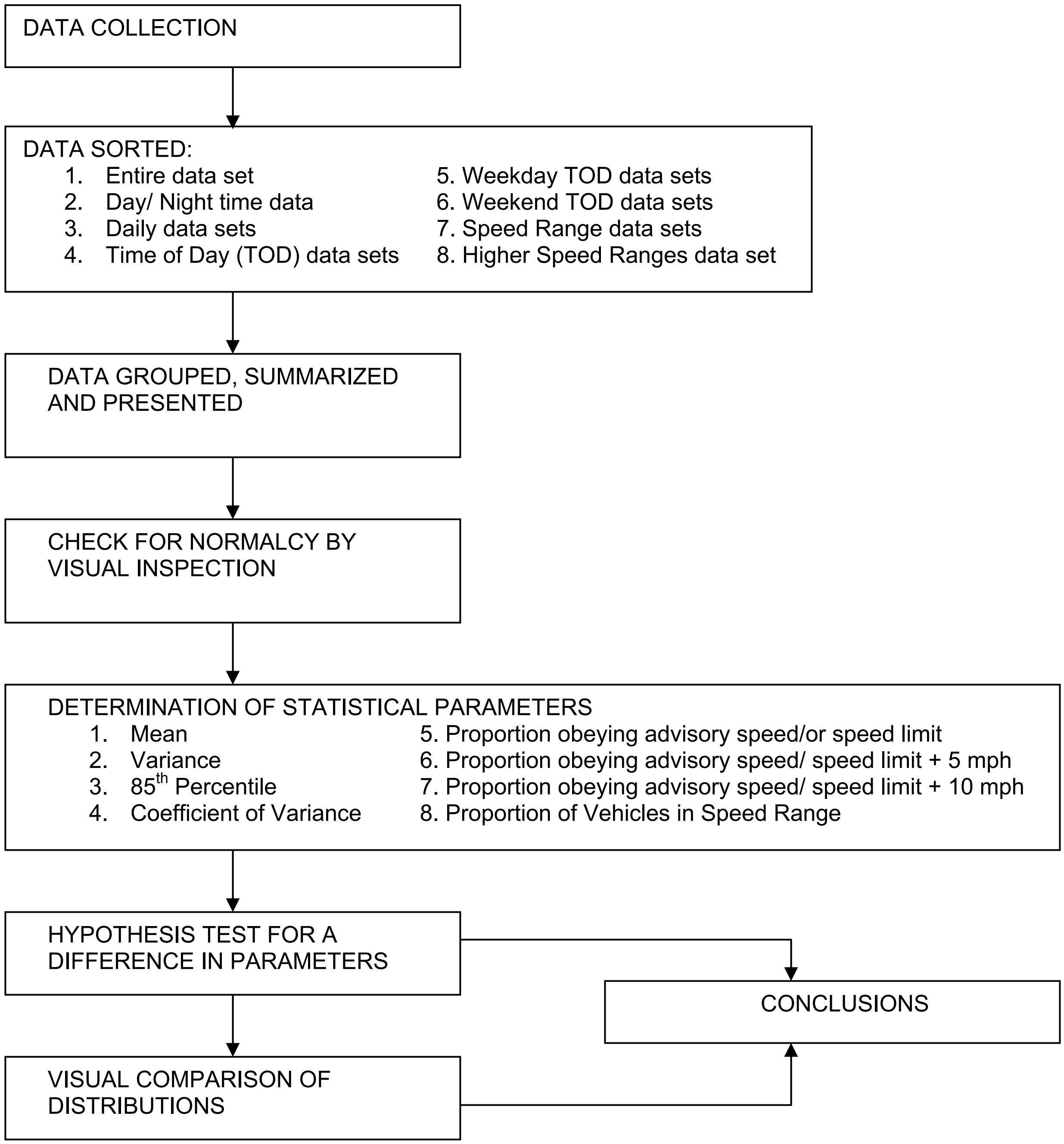


Figure 3-26: Speed Data Analysis Steps

4 ANALYSIS OF CRASH, GEOMETRIC AND RAINFALL DATA

4.1 Crash Data and Analysis

Accident data for the US 27/ US 192 interchange was obtained from the Polk County Traffic Engineering Department and the Lake County Traffic Engineering Department for the years 1996 to 2004 (see Appendix A)The information is first presented for the entire interchange and then for the southbound entry study ramp.

US 27/ US 192 Interchange

Between the years 1996 and 2004 there were ninety-five (95) total crashes that occurred on the interchange ramps. The majority of these crashes, forty-six (46) or approximately 50%, were overturned crashes. Figure 4-1 presents a break down of the types of crashes that occurred.

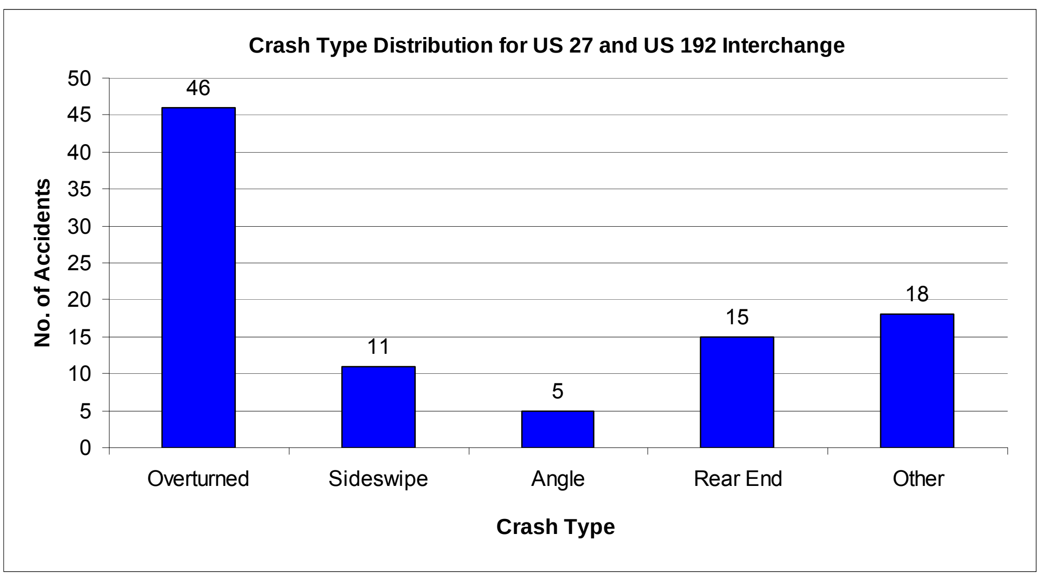


Figure 4-1: Crash Type Distribution for Crashes at the US 27/ US 192 Interchange

Figure 4-2 shows a break down of the contributing causes as recoded by the law officer. Fourthly-six (46) of the crashes were due to careless driving, eighteen (18) were due to motorists exceeding the speed limit, ten (10) were recorded as no improper action, and twenty-one (21) were recorded as other. (Note: Careless driving was a category within the short and long form crash data and was a subjective reason provided by the recording law officer).

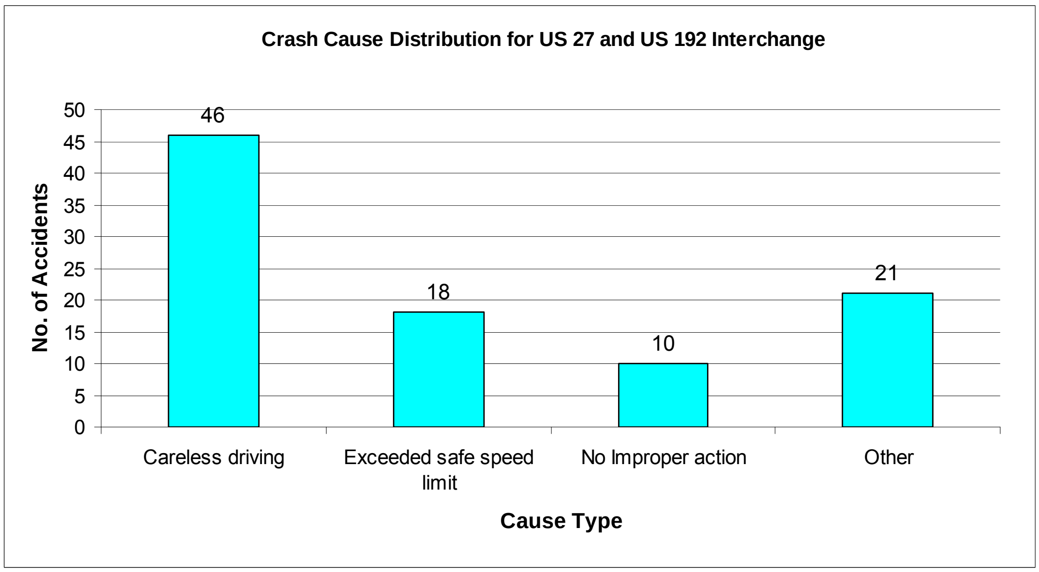


Figure 4-2: Crash Cause Distribution for Crashes at the US 27/ US 192 Interchange

Further investigation into only the overturned crashes revealed that most, 20 crashes or 43%, were caused by careless driving, 15 crashes or 32 % were caused by motorists exceeding the speed limit, two (2) were recorded as no improper action, and one (1) was recorded as other. This is illustrated in Figure 4-3.

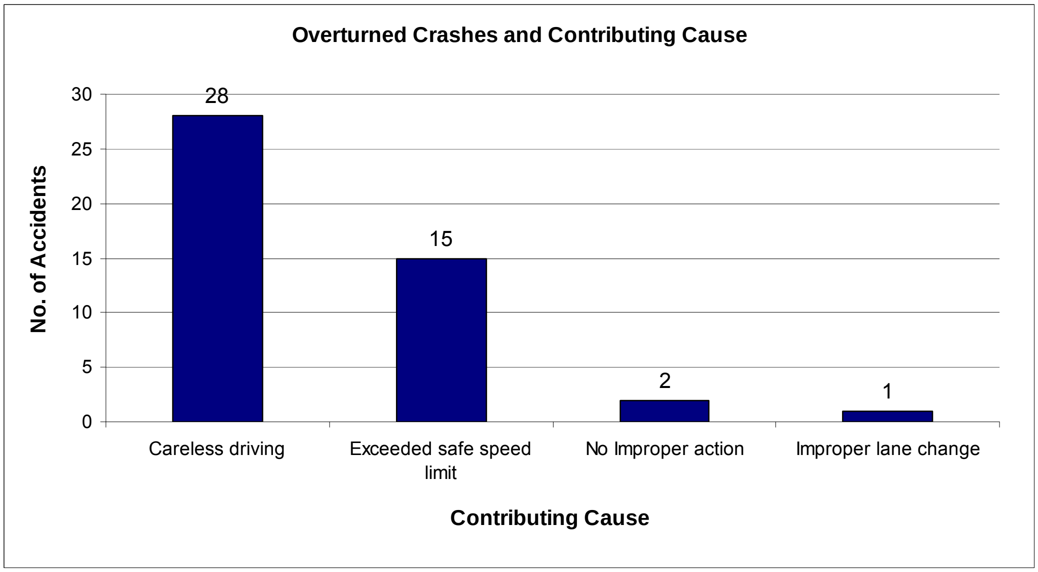


Figure 4-3: Overturned Crashes and Contributing Cause at the US 27/ US 192 Interchange

Figure 4-4 provides a break down of the overturned crashes and the day on which they occurred. In general, it was seen that there were more crashes that occurred on the weekend than during the week.

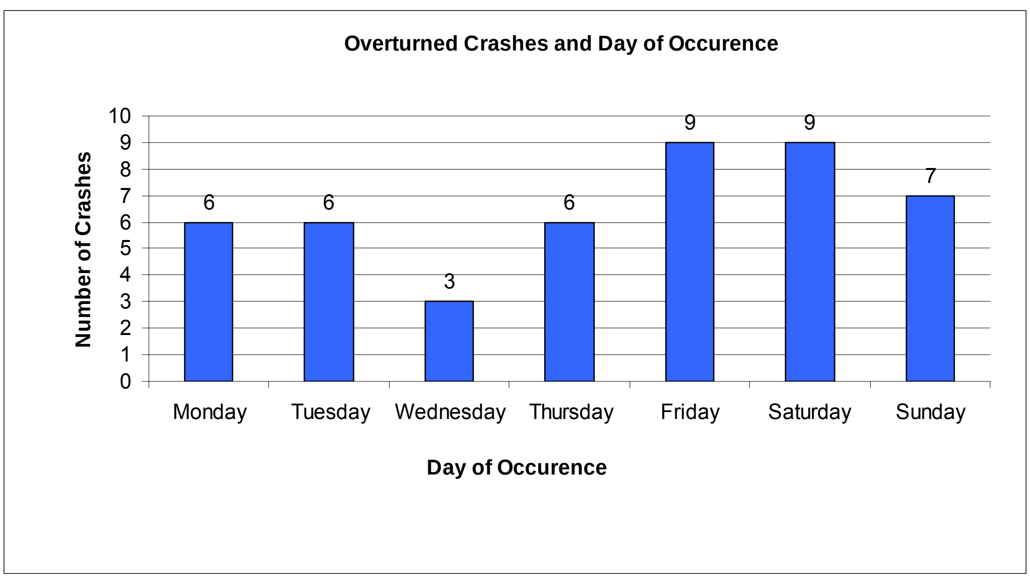


Figure 4-4: Overturned Crashes and Day of Occurrence

Figure 4-5 shows a break down of the all crashes by the ramp on which they occurred. The vast majority of the crashes, 56% or fifty-four (54) crashes, occurred on the southbound entry ramp. Fifteen (15) crashes occurred on the southbound exit ramp, fourteen (14) crashes occurred on the northbound entry, and twelve (12) occurred on the northbound exit ramp.

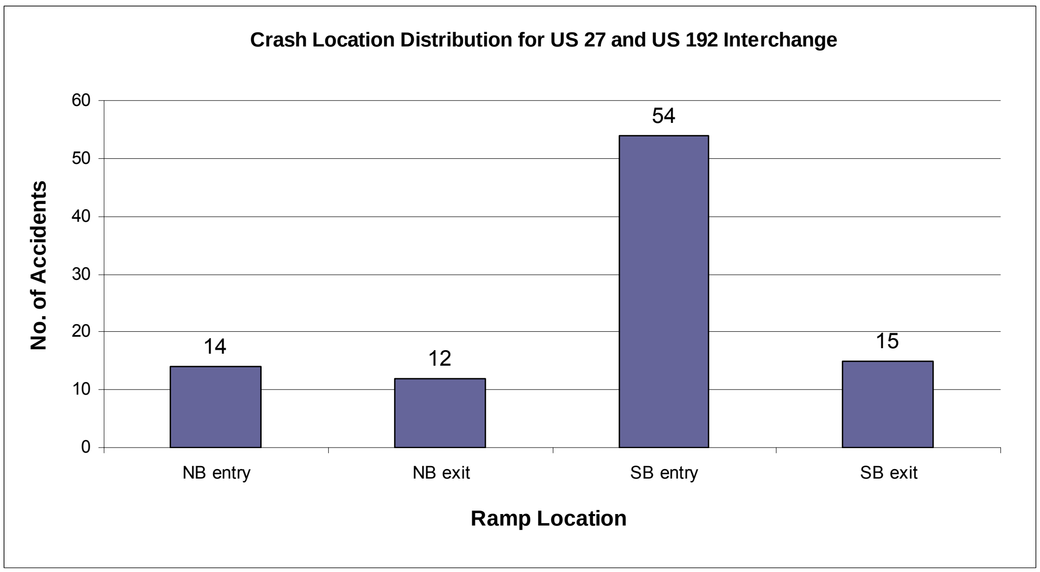


Figure 4-5: Crash Location Distribution for Crashes at the US 27/ US 192 Interchange

Figure 4-6 shows the crashes per year. The data shows no specific growth rate as there were crash reductions, as compared to the previous years, in 1997, 2001, and 2003. In 2004, there were nineteen (19) crashes that occurred and this was a notable increase as compared to all other years.

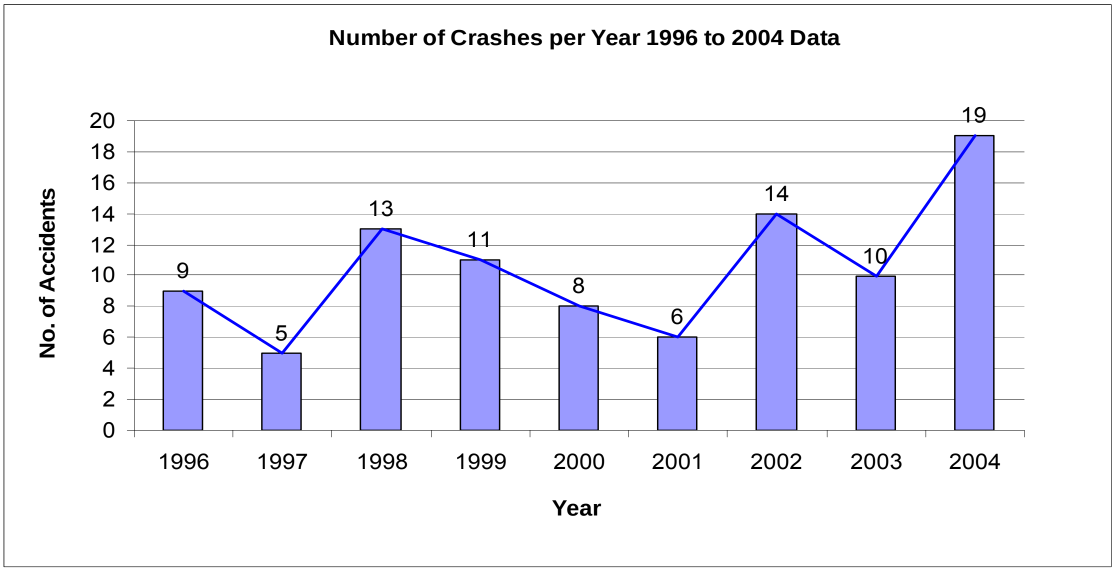


Figure 4-6: Number of Crashes Per Year at the US 27/ US 192 Interchange

<u>Southbound Entry Ramp</u>

Between the years 1996 and 2004 there were fifty-four (54) total crashes that occurred on the southbound entry study ramp. Thirty (30), or approximately 56%, of these crashes were overturned crashes. Figure 4-7 presents a break down of the types of crashes that occurred on the southbound entry ramp.

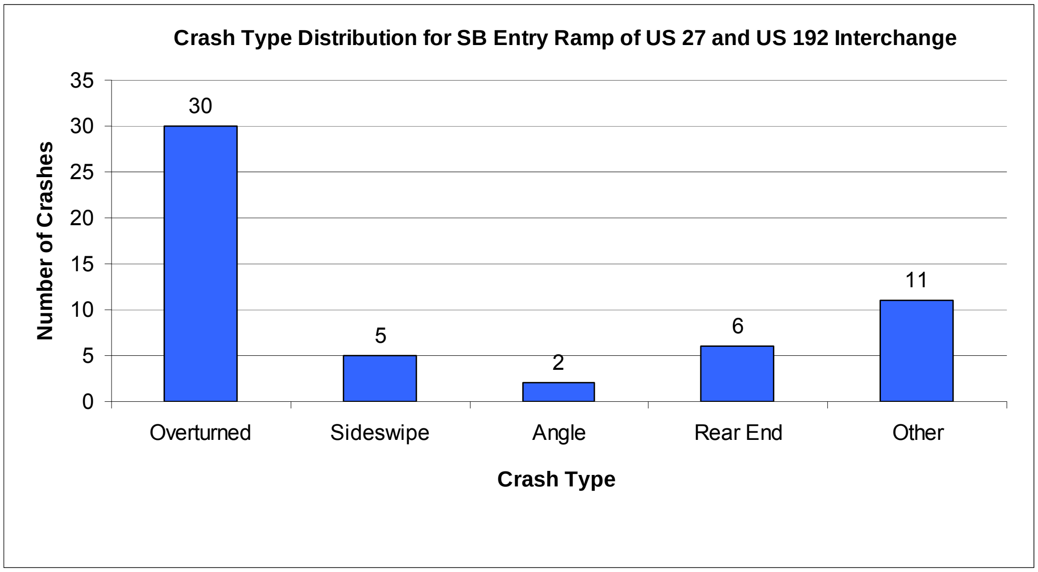


Figure 4-7: Crash Type Distribution for Crashes at SB Entry Ramp

Figure 4-8 shows a break down of the contributing causes to the crashes on the southbound entry ramp as recoded by the law officer. Twenty-six (26) of the crashes were due to careless driving, fourteen (14) were due to motorists exceeding the speed limit, five (5) were recorded as no improper action, and nine (9) were recorded as other. The crashes due to careless driving and motorist exceeding the speed limit accounted for approximately 74% of the crashes that occurred on the study ramp.

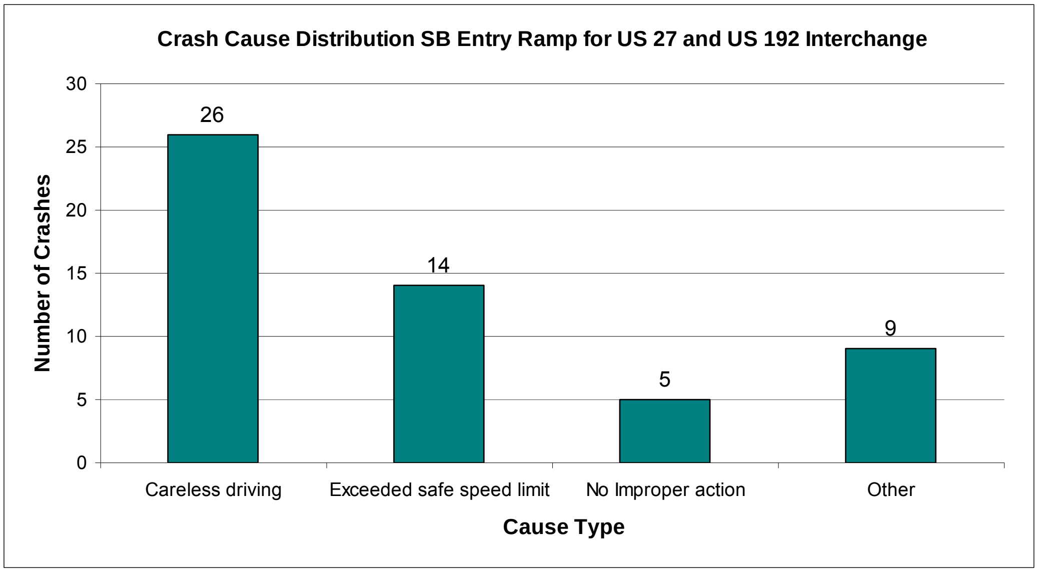


Figure 4-8: Crash Cause Distribution for Crashes at SB Entry Ramp

Figure 4-9 below provides pie charts of the crashes based upon occurrence during day or night conditions or during wet or dry conditions. Approximately equal percentages of crashes occurred during the day and night. Sixty-seven percent (67%) of the crashes occurred during dry conditions and thirty-three percent (33%) occurred during wet conditions.

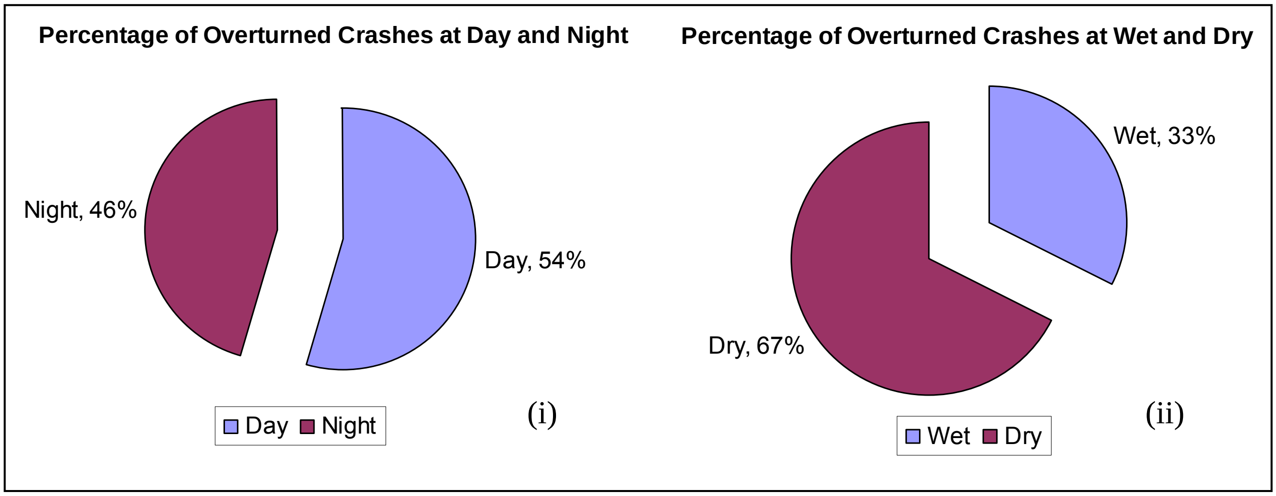


Figure 4-9: Percentage of Day/ Night and Wet/ Dry Crashes at SB Entry Ramp

Figure 4-10 below shows that approximately equal percentages of crashes were property damage only (PDO) and injury crashes. There were no fatal crashes recorded on the southbound entry ramp.

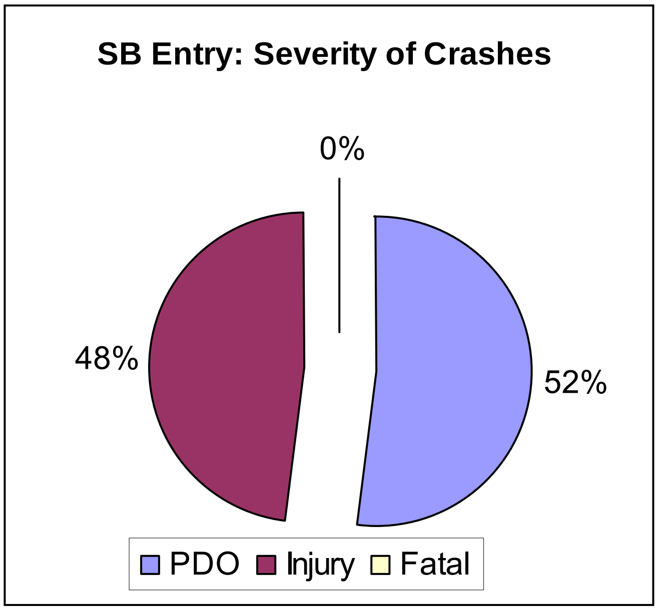


Figure 4-10: Crash Severity Percentages at the SB Entry Ramp

Figure 4-11 shows the overturned crashes per year that occurred on the SB entry ramp. The data shows no specific trend and no overturned crashes occurred in 2001 and 2004.

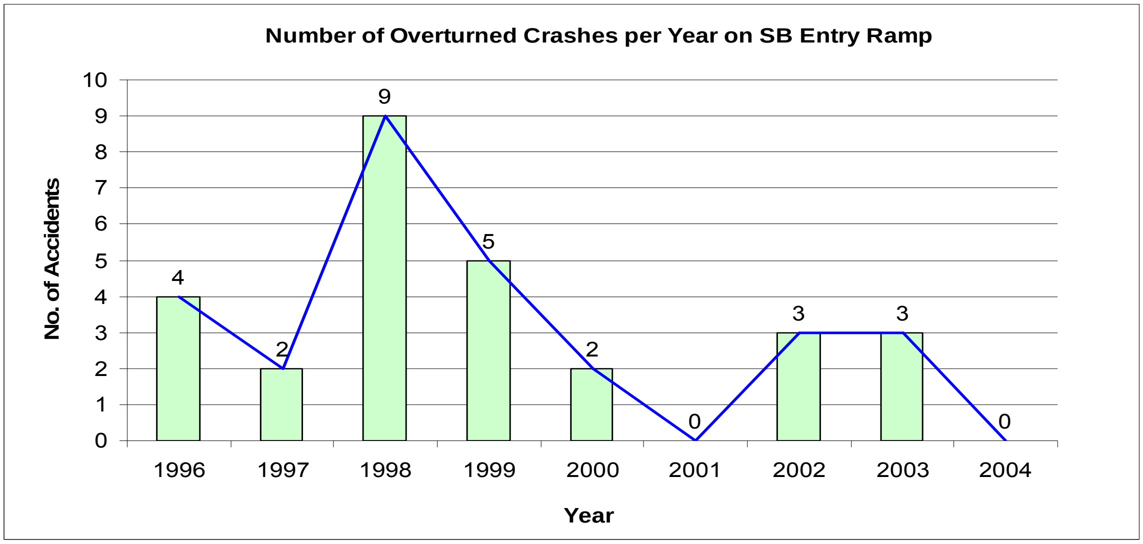


Figure 4-11: Overturned Crashes per Year on SB Entry Ramp between 1996 & 2004

Figure 4-12 provides a yearly crash rate comparison of crashes that occurred on the southbound entry ramp between 1996 and 2004. There was a marked reduction in crashes from 2000 onwards and this coincided with the milling and resurfacing and signage improvements completed in that year.

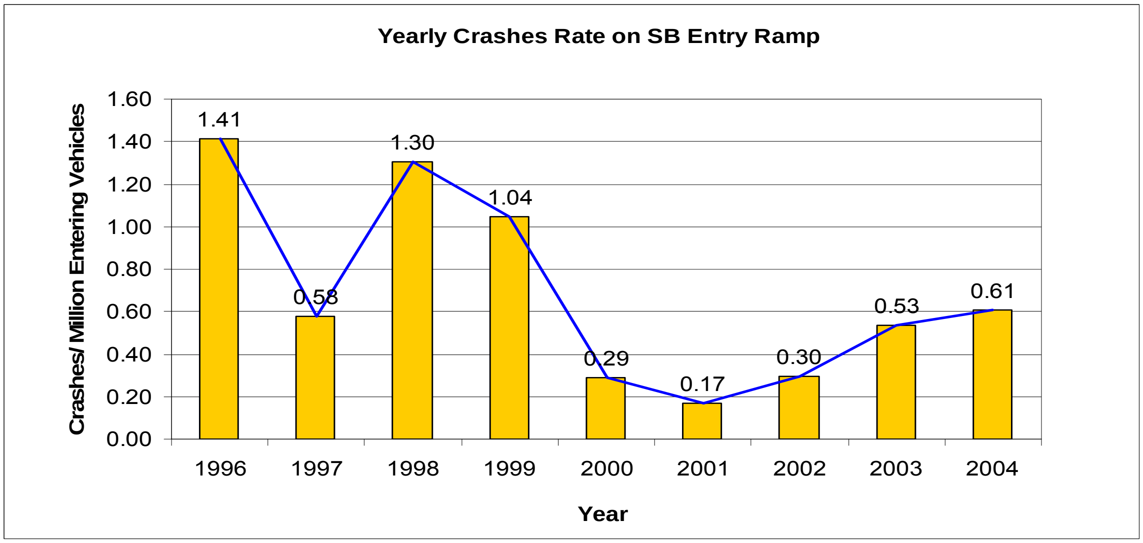


Figure 4-12: Crashes at SB Entry Ramp per Million Entering Vehicles on US 192 Mainline

Summary

The interchange crash data indicated that there was clearly an overturning crash problem at the interchange since approximately 50% of the crashes were of that type. Investigations into the overturned crashes indicated that most of the crashes, 75%, were due to careless driving or motorists exceeding the speed limit. The analysis also indicated that more overturned crashes occurred on the weekend (Friday, Saturday and Sunday) than occurred during the week. The data also indicated that 56% of all the crashes at the interchange occurred on the SB entry study ramp. For the overall interchange no specific growth rate was seen but the average crashes per year in the years 2002 to 2004 was higher (14.33) than that from the years 1996 to 2001 (8.67).

The southbound entry study ramp followed similar trends as the total interchange data in terms of crash type and contributing cause. More crashes occurred during the day than at night and was most likely because there was a greater volume during the day hence increasing the chances of a crash occurring. Crashes occurred in approximately equal percentages during the day and night and dry or wet conditions. There were approximately equal percentages of property damage only and injury crashes. Crashes on the study ramp decreased from 2000 onwards and this coincided with the milling and resurfacing and signage improvements completed in that year.

4.2 Existing Geometry Analysis

4.2.1 Existing Geometry Data

Figure 4-13 and Figure 4-14 show copies of the geometric design data and sign location information received from FDOT. The design plans are hand drawn and date back to 1969.

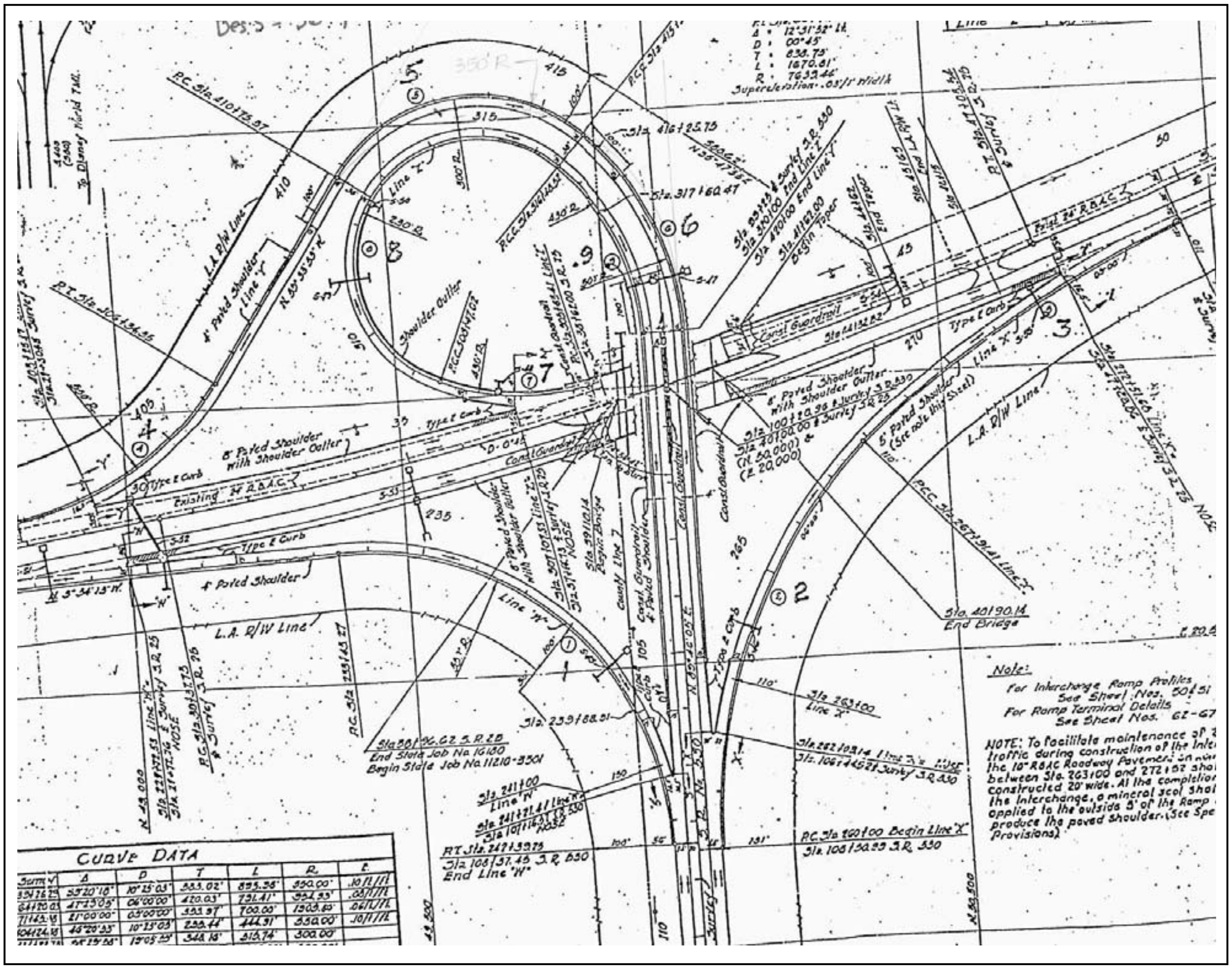


Figure 4-13: Geometric Design Data (FDOT Project No. 16180-509)

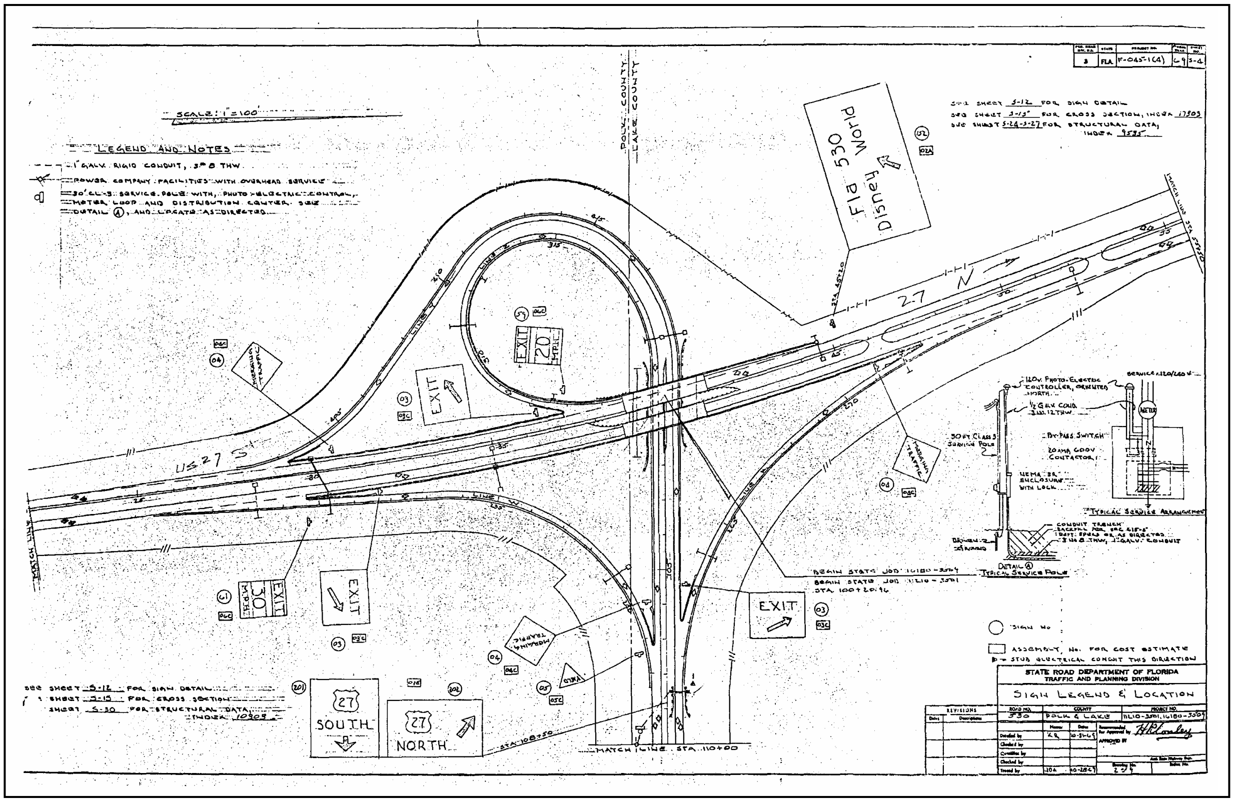


Figure 4-14: Sign and Legend Location (FDOT Project No. 16180-509)

4.2.2 Geometric Data Analysis

The southbound entry ramp (study ramp) at the US 27/ US 192 interchange comprises a 2 radii compound curve (see Figure 4-15). The radius of preceding curve (5) is 500-feet and the following curve (6) is 300 feet and this gives a ratio of the flatter curve to the sharper curve of 1.67:1 which is within standard AASHTO guidelines of 1.75:1. The length of both curves are 500-feet or greater and are larger than the minimum desirable AASHTO arc lengths for compound curves (see Table 2-3). The sign is currently posted at an advisory speed of 35 mph and would typically be designed for 40 mph, minimum. FDOT guidelines associated with this design speed requires a curve radii of 432-feet ($D_{max} = 13^{0}15'$) at a maximum superelevation

(e_{max}) of 10%. Curve 5 is designed more in keeping with a 30 mph design speed ($D_{max} = 17^{0}45'$ and maximum super elevation e_{max} = 10%) and a curve at this design speed would typically be posted at an advisory speed of 25 mph.

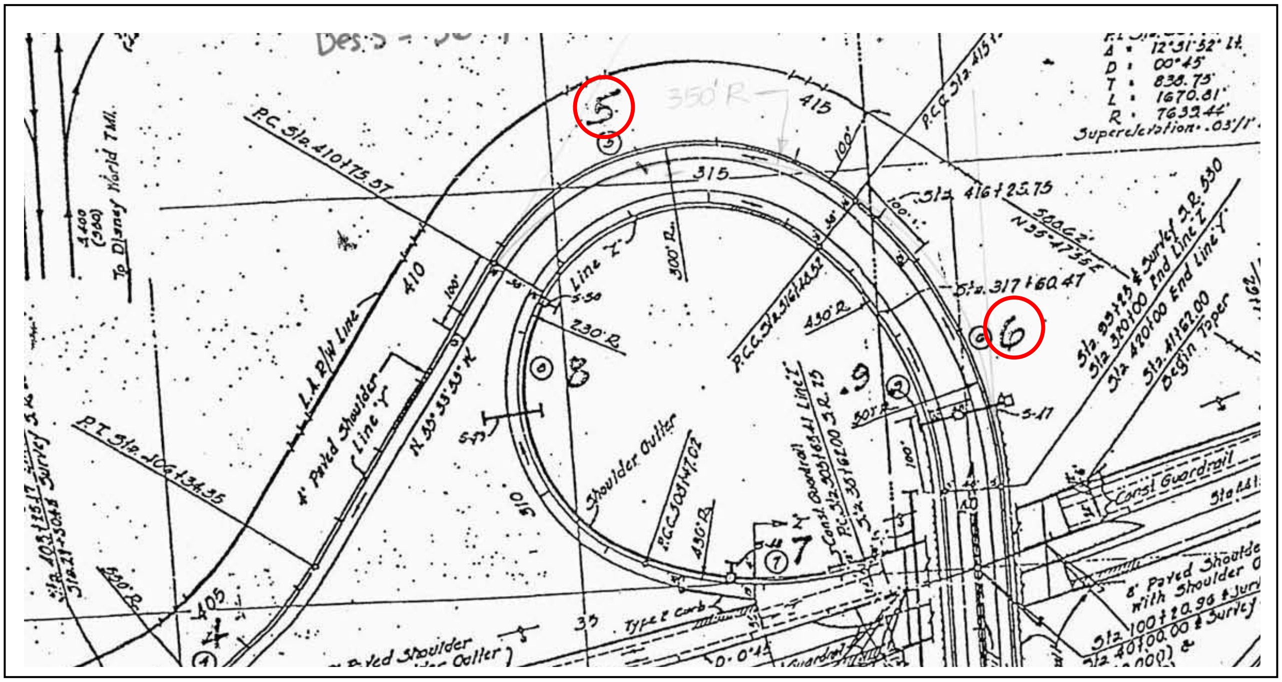


Figure 4-15: Study Ramp Geometric Design Information

In addition to these geometric design factors, the bridge over US 192 effectively serves to “hide” the study ramp. The curve is not visible to approaching vehicles heading west along US 192 until they pass under the bridge. This is shown in Figure 4-16. It can be postulated that the curve could potentially surprise unfamiliar drivers since they do not perceive the roadway alignment stimulus to slow down until passing the bridge. In addition, the speed limit on both US 192 and US 27 is 55 mph. Motorists traveling at the speed limit (55mph) along US 192, have to reduce their speed by 20 mph to 35 mph (if the advisory speed was followed) while navigating the curve and then accelerate again to 55 mph in order to merge into US 27. It can be postulated that drivers familiar with the interchange tend to try to maintain their high speed while navigating the ramp because they know they will have to accelerate afterwards.

It can be concluded that a combinations of the small radii following curve, lack of sufficient roadway alignment stimulus to warn of a curve, and high speeds on the interchanging roadways contribute to the vehicle off-tracking at the study ramp. Evidence of this off-tracking can be seen in Figure 4-17.

Figure 4-16: View as Vehicles Approach Study Ramp

Figure 4-17: Evidence of Vehicle Off-Tracking at Study Ramp

4.3 Rainfall Data Analysis

Approach Data

Table 4-1 provides a summary of the daily rainfall totals on Approach speed data collection days Before and After the DSM system was installed. There were more average rainfall and total rainfall during the After condition (as shown in After-Initial column). Consequently the rainy days (highlighted in blue) were further investigated to determine when storms occurred and the appropriate time periods (day AM, day PM, night AM, night PM) for that data set were replaced with data from a non-rainy day for a similar time period. The final resulting data set is shown under the After–Final column.

Table 4-1: Approach Speed Data Collection Days - Daily Rainfall Summary

No.	Rainfall Sum (in)		Rainfall Sum (in)			
	BEFORE		AFTER - Initial		AFTER - Final	
	Date	Lake Buena Vista	Date	Lake Buena Vista	Date	Lake Buena Vista
1	Sun, May 20	0.00	Sun, Jul 01	1.81	Sun, Jul 15	0.45
2	Mon, May 21	0.03	Mon, Jul 02	0.02	Mon, Jul 02	0.02
3	Tue, May 22	0.00	Tue, Jul 03	0.02	Tue, Jul 03	0.02
4	Wed, May 23	0.00	Wed, Jul 18	0.00	Wed, Jul 18	0.00
5	Thu, May 24	0.08	Thu, Jul 05	0.11	Thu, Jul 05	0.11
6	Fri, May 25	0.00	Fri, Jul 06	1.31	Fri, Jul 20	0.00
7	Sat, May 26	0.03	Sat, Jul 07	0.00	Sat, Jul 07	0.00
8	Thu, Jun 07	0.05	Sun, Jul 08	0.00	Sun, Jul 08	0.00
9	Fri, Jun 08	0.27	Mon, Jul 09	0.00	Mon, Jul 09	0.00
10	Sat, Jun 09	0.00	Tue, Jul 10	0.19	Tue, Jul 10	0.19
11	Sun, Jun 10	0.55	Wed, Jul 11	0.22	Wed, Jul 11	0.22
12	Mon, Jun 11	0.08	Thu, Jul 12	0.00	Thu, Jul 12	0.00
13	Tue, Jun 12	0.01	Fri, Jul 13	0.00	Fri, Jul 13	0.00
14	Wed, Jun 13	0.77	Sat, Jul 14	0.00	Sat, Jul 14	0.00
	Avg. Rainfall (in)	**0.13**	**Avg. Rainfall (in)**	**0.26**	**Avg. Rainfall (in)**	**0.07**
	Total Rain fall (in)	**1.87**	**Total Rain fall (in)**	**3.68**	**Total Rain fall (in)**	**1.01**
	Days with Rain	**9**	**Days with Rain**	**7**	**Days with Rain**	**6**

- Rainy days for which data was partially replaced

PC Data

Table 4-2 provides a summary of the daily rainfall totals on PC speed data collection days Before and After the DSM system was installed. There were more average rainfall, total rainfall, and days that rain fell during the After condition (After-Initial column). Consequently the rainy days (highlighted in blue) were further investigated to determine when storms occurred and the appropriate time periods (day AM, day PM, night AM, night PM) for that data set were replaced with data from a non-rainy day for a similar time period. It was not possible to replace the Wednesday, June 13 data, which had 0.77 inches of rainfall, due to data limitations. The final resulting data set is shown under the After–Final column.

Table 4-2: PC Speed Data Collection Days - Daily Rainfall Summary

No.	Rainfall Sum (in)		Rainfall Sum (in)			
	BEFORE		AFTER - Initial		AFTER - Final	
	Date	Lake Buena Vista	Date	Lake Buena Vista	Date	Lake Buena Vista
1	Tue, May 29	0.00	Wed, Jun 13	0.77	Wed, Jun 13	0.77
2	Wed, May 30	0.00	Thu, Jul 05	0.11	Thu, Jul 05	0.11
3	Thu, May 31	0.00	Fri, Jul 06	1.31	Fri, Jul 13	0.00
4	Fri, Jun 01	0.44	Sat, Jul 07	0.00	Sat, Jul 07	0.00
5	Sat, Jun 02	1.06	Sun, Jul 08	0.00	Sun, Jul 08	0.00
6	Sun, Jun 03	0.00	Mon, Jul 09	0.00	Mon, Jul 09	0.00
7	Mon, Jun 04	0.00	Tue, Jul 10	0.19	Tue, Jul 10	0.19
	Avg. Rainfall (in)	**0.21**	**Avg. Rainfall (in)**	**0.34**	**Avg. Rainfall (in)**	**0.15**
	Total Rain fall (in)	**1.50**	**Total Rain fall (in)**	**2.38**	**Total Rain fall (in)**	**1.07**
	Days with Rain	**2**	**Days with Rain**	**4**	**Days with Rain**	**3**

- Rainy days for which data was partially replaced

5 SPEED DATA ANALYSIS

The tables and graphs in this section present the data set summaries for Approach and PC speed data as collected Before and After the installation of the DSM system. Data is presented for the Entire data set, Day and Night time data sets, Daily data sets, Time of Day or TOD data sets, Weekdays TOD data set, Weekend TOD data set, Speed ranges data sets, and Higher speed ranges data sets. The specifics of each data set were discussed in Section 3.4.4 of the Methodology Chapter. For some data sets, the frequency percentage (frequency in that particular speed bin divided by the total frequency for that category of data) was plotted so that a comparison of percentage frequency could be illustrated instead of total frequency. Possible reasons are also provided for any observations or trends seen in each data set. The analysis sheets are provided in Appendix B and Appendix C.

5.1 Before and After Approach Speed Data

5.1.1 Entire Data Set – Before and After Approach Speeds

Table 5-1 presents the Before and After data and statistical parameters for the Approach speeds Entire data set. Table 5-2 presents the summary of the hypothesis tests results. Figure 5-1 provides a frequency graph and Figure 5-2 provides a cumulative frequency.

Table 5-1 shows that the mean decreased by 3.58 mph and the variance by 3.34. Speed limit compliance increased by 22.27 %.

Table 5-1: Before and After Approach Speeds Entire Data Set Summary

Speed Bins (mph)	Before Vehicle Frequency		After Vehicle Frequency	
	Proportion of Total	Frequency	Proportion of Total	Frequency
1 to 30	0.001	48	0.001	61
31 to 32	0.000	17	0.002	70
33 to 35	0.002	65	0.006	251
36 to 38	0.004	165	0.015	604
39 to 41	0.013	485	0.033	1345
42 to 44	0.030	1174	0.076	3086
45 to 47	0.067	2582	0.127	5200
48 to 50	0.129	4954	0.201	8199
51 to 53	0.174	6684	0.197	8038
54 to 56	0.207	7991	0.173	7054
57 to 59	0.164	6310	0.094	3853
60 to 62	0.114	4406	0.045	1853
63 to 65	0.053	2025	0.018	731
66 to 68	0.025	949	0.007	294
69 to 147	0.017	660	0.004	181
Total	**1.00**	**38515**	**1.00**	**40820**
Average Speed (mph)	**---**	**54.63**	**---**	**51.05**
Variance	**---**	**41.29**	**---**	**37.95**
Coefficient of Variance	**---**	**0.12**	**---**	**0.12**
% Obeying Speed Limit	**---**	**55.95**	**---**	**78.22**
% Obeying Speed Limit + 5 Mph	**---**	**83.74**	**---**	**94.44**
% Obeying Speed Limit + 10 Mph	**---**	**95.82**	**---**	**98.84**
85^{th} Percentile (mph)	**---**	**61.00**	**---**	**57.00**

Table 5-2: Before and After Approach Speeds Entire Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change	Significant?
Means	μ (b) - μ (a) > 0	-3.58 mph	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	-3.34	Yes
% Obeying Speed Limit	P (b) - P (a) < 0	22.27%	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	10.70%	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	3.01%	Yes

The 85th percentile speed was reduced from 61 mph to 57 mph, and the coefficient of variation was unchanged. From Table 5-2 it was seen that mean and variance reduction as well as proportion increase was significant. Figure 5-1 and Figure 5-2 show clearly that the After distribution of speeds shifts to the lower speed bins as compared to the Before speeds.

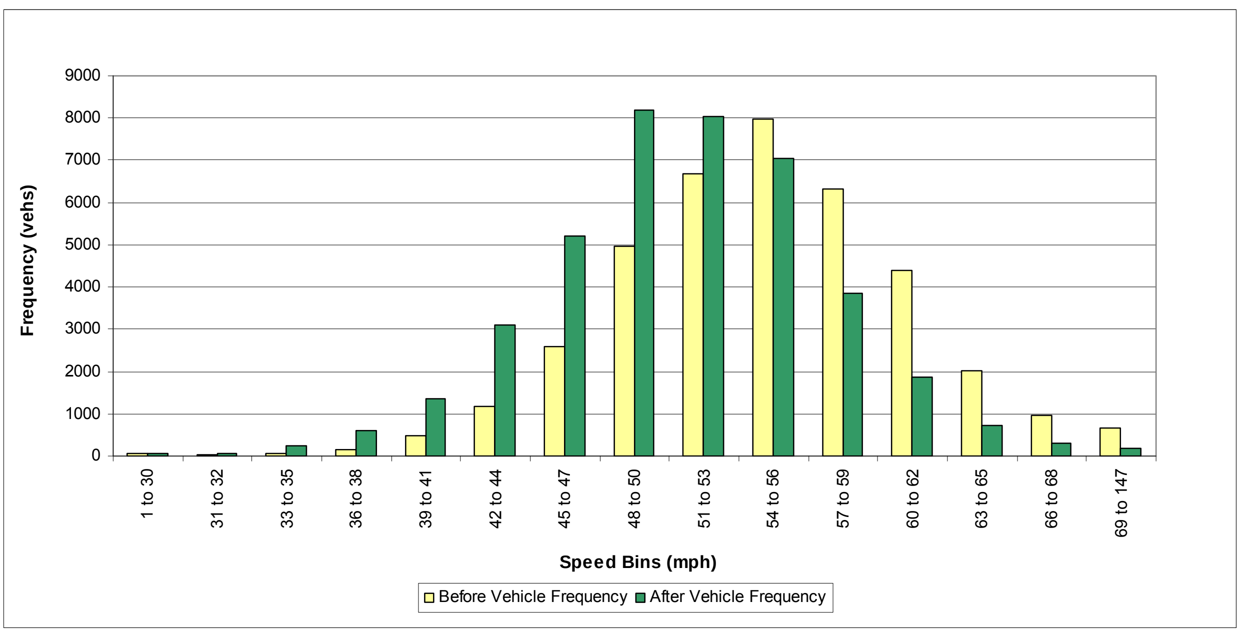


Figure 5-1: Before and After Approach Speeds Entire Data Set Graph

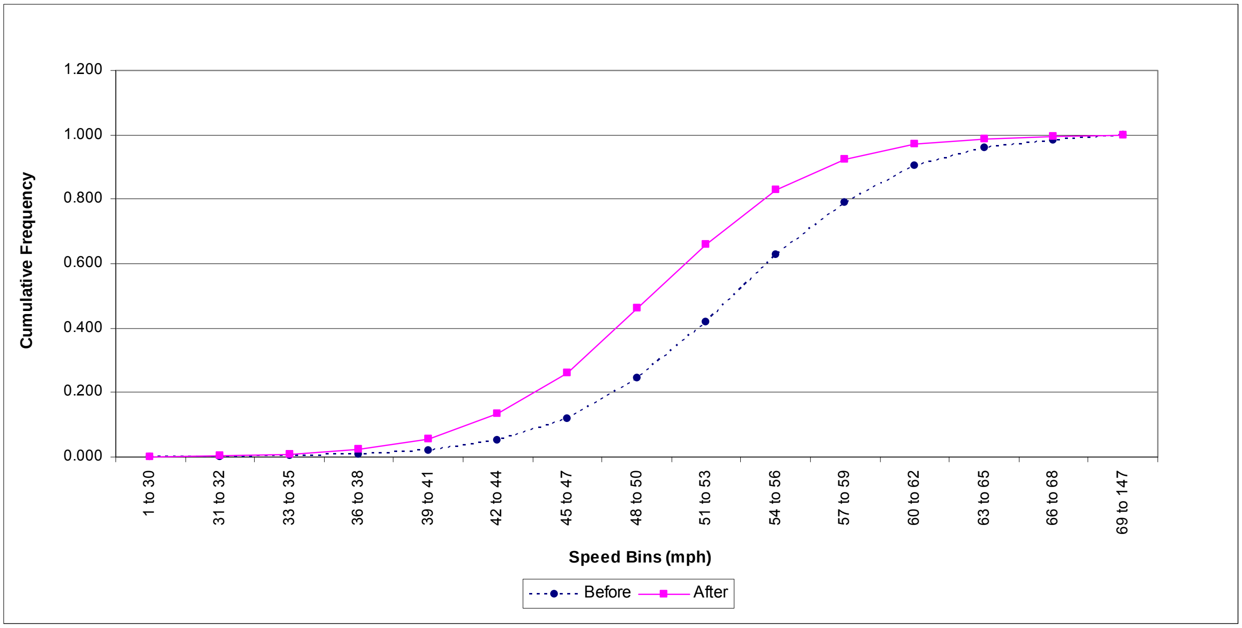


Figure 5-2: Before and After Approach Speeds Entire Data Set Cumulative Distributions

5.1.2 Day Time and Night Data Set - Before and After Approach Speeds

Table 5-3 presents the Before and After data and statistical parameters for the Approach speeds Day and Night time data sets. Table 5-4 presents the summary of the hypothesis tests results. Figure 5-3 and Figure 5-5 provides frequency graphs of the Before and After speeds and Figure 5-4 and Figure 5-6 provides cumulative frequency graphs for the Day and Night time data respectively.

Table 5-3: Before and After Approach Speeds Day and Night Time Data Set Summary

Speed (mph)	Before Vehicle Frequency				Total	After Vehicle Frequency				Total
	Proportion		Frequency			Proportion		Frequency		
	Day	Night	Day	Night		Day	Night	Day	Night	
1 to 30	0.001	0.001	33	15	**48**	0.001	0.003	25	36	**61**
31 to 32	0.000	0.001	10	7	**17**	0.001	0.002	38	32	**70**
33 to 35	0.002	0.002	41	24	**65**	0.005	0.009	133	118	**251**
36 to 38	0.004	0.006	93	72	**165**	0.012	0.020	337	267	**604**
39 to 41	0.011	0.016	284	201	**485**	0.027	0.045	756	589	**1345**
42 to 44	0.028	0.037	712	462	**1174**	0.069	0.090	1901	1185	**3086**
45 to 47	0.062	0.077	1609	973	**2582**	0.119	0.144	3300	1900	**5200**
48 to 50	0.116	0.153	3012	1942	**4954**	0.195	0.214	5376	2823	**8199**
51 to 53	0.166	0.189	4298	2386	**6684**	0.201	0.188	5553	2485	**8038**
54 to 56	0.205	0.213	5298	2693	**7991**	0.185	0.148	5102	1952	**7054**
57 to 59	0.173	0.145	4475	1835	**6310**	0.103	0.076	2846	1007	**3853**
60 to 62	0.126	0.090	3263	1143	**4406**	0.050	0.036	1383	470	**1853**
63 to 65	0.058	0.041	1503	522	**2025**	0.019	0.015	536	195	**731**
66 to 68	0.029	0.017	738	211	**949**	0.008	0.005	226	68	**294**
69 to 147	0.019	0.013	491	169	**660**	0.004	0.004	124	57	**181**
Total Vehicles			**25860**	**12655**	**38515**	---	---	**27636**	**13184**	**40820**
Average Speed (mph)			**55.06**	**53.75**	**---**	---	---	**51.50**	**50.11**	**---**
Variance			**41.41**	**39.90**	**---**	---	---	**36.53**	**39.62**	**---**
Coefficient of Variance			**0.12**	**0.12**	---	---	---	**0.12**	**0.13**	---
% Obeying Speed Limit			**52.66**	**62.66**	---	---	---	**76.26**	**82.33**	---
% Obeying Speed Limit + 5 Mph			**81.86**	**87.59**	---	---	---	**93.89**	**95.59**	---
% Obeying Speed Limit + 10 Mph			**95.25**	**97.00**	---	---	---	**98.73**	**99.05**	---
85th Percentile (mph)			**61.00**	**60.00**	**---**	---	---	**57.00**	**56.00**	**---**

Table 5-4: Before and After Approach Speeds Entire Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change		Significant?	
		Day Time	Night Time	Day Time	Night Time
Means	μ (b) - μ (a) > 0	-3.56	-3.64	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	-4.87	-0.28	Yes	Yes
% Obeying Speed Limit	P (b) - P (a) < 0	23.60%	19.67%	Yes	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	12.03%	8.00%	Yes	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	3.49%	2.06%	Yes	Yes

Table 5-3 shows that the mean decreased by 3.56 mph and 3.64 mph and the variance decreased by 4.88 and 0.28 for the Day and Night data set respectively. This indicated that the DSM system was not as effective at night in reducing variance. Speed limit compliance increased by 23.60% and 19.67% and the 85th percentile speed was reduced from 61 mph to 57 mph and 60 mph to 56 mph for the Day and Night data sets respectively. The coefficient of variation was unchanged for both data sets. From Table 5-4 it was seen that that mean and variance reduction as well as proportion increase was significant. Figure 5-3 to Figure 5-6 show clearly that the After distribution of speeds shifts to the lower speed bins as compared to the Before speeds.

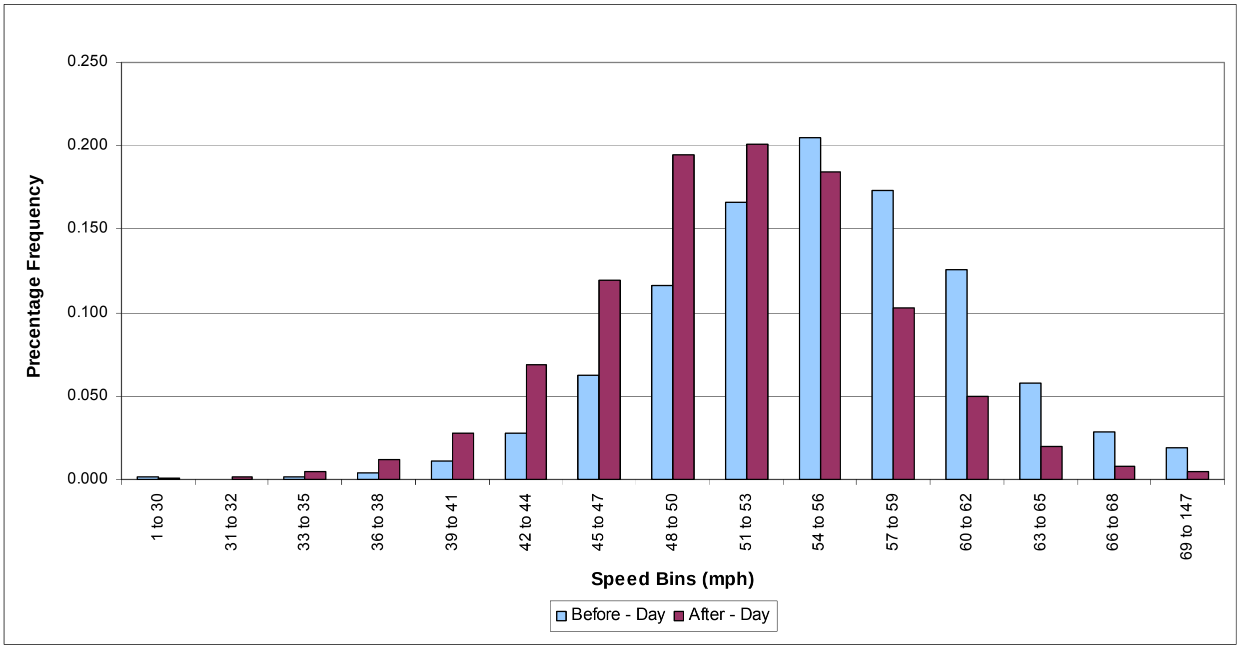


Figure 5-3: Before and After Approach Speeds Day Time Frequency Graph

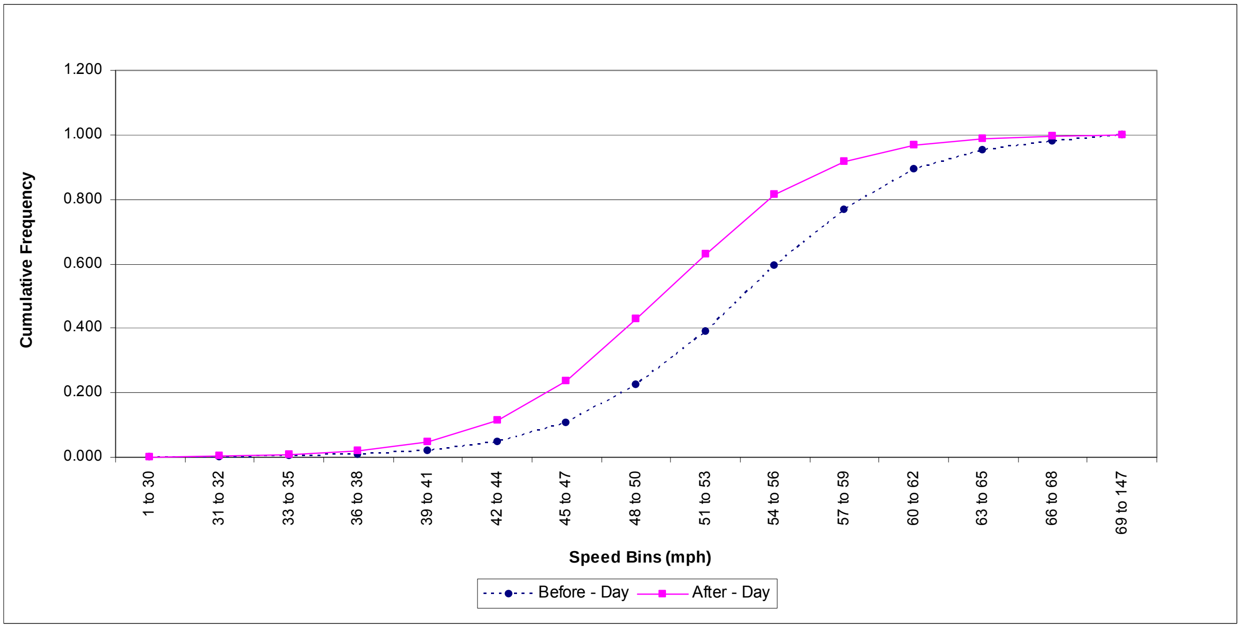


Figure 5-4: Before and After Approach Day Time Speeds Cumulative Distributions

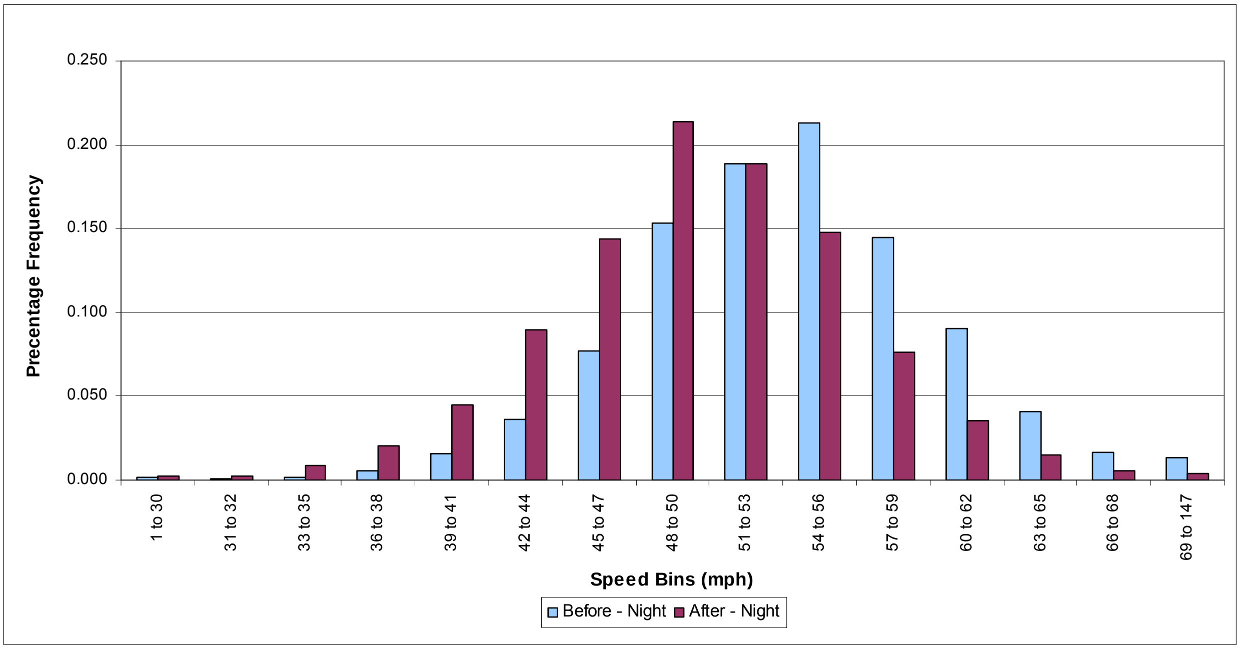


Figure 5-5: Before and After Approach Speeds Night Time Frequency Graph

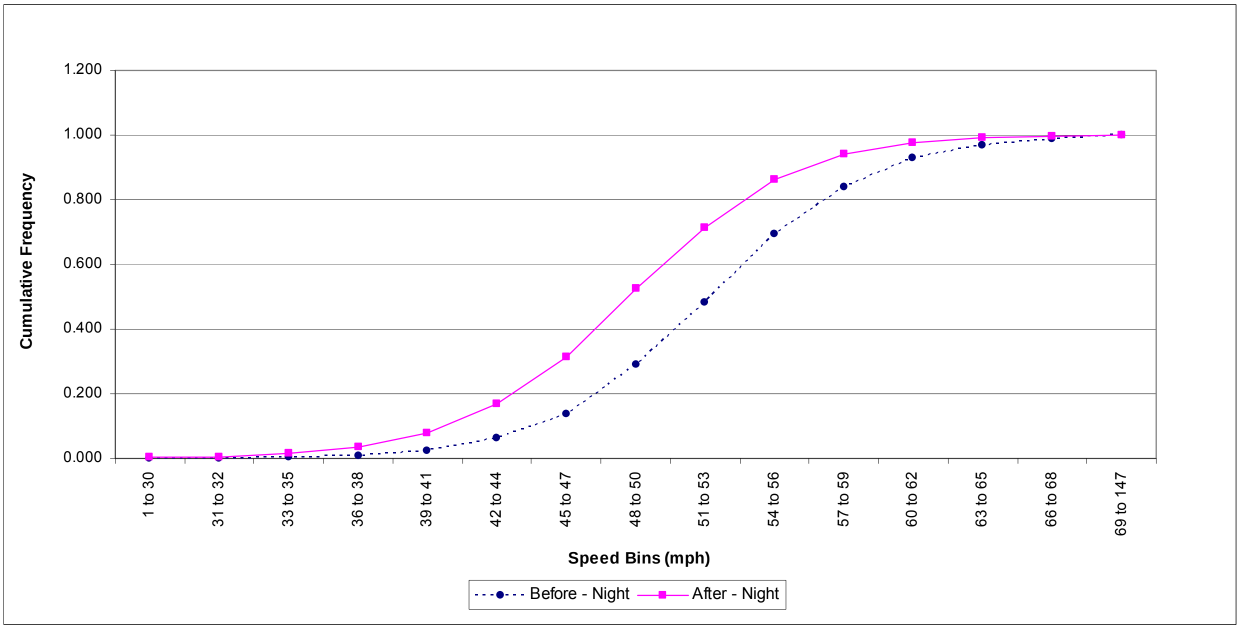


Figure 5-6: Before and After Approach Night Time Speeds Cumulative Distributions

5.1.3 Daily Data Set - Before and After Approach Speeds

Table 5-5 presents the Before and After data and statistical parameters for the Approach speeds Daily data sets. Table 5-6 presents the summary of the hypothesis tests results. Figure 5-7 to Figure 5-12 provides frequency graphs of the Before and After speeds for the data sets.

Table 5-5: Before and After Approach Speeds Daily Data Set Summary

Speed (mph)	Before Daily Vehicle Frequency								After Daily Vehicle Frequency							
	05/22/07 & 6/12/2007 Tue	05/23/07 & 6/13/2007 Wed	05/24/07 & 6/07/2007 Thu	05/25/07 & 6/08/2007 Fri	05/26/07 & 6/09/2007 Sat	05/20/07 & 6/10/2007 Sun	05/21/07 & 6/11/2007 Mon	Total	07/03/07 & 7/10/2007 Tue	07/18/07 & 7/11/2007 Wed	07/05/07 & 7/12/2007 Thu	07/20/07 & 7/13/2007 Fri	07/07/07 & 7/14/2007 Sat	07/15/07 & 7/08/2007 Sun	07/02/07 & 7/09/2007 Mon	Total
1 to 30	1	9	5	7	15	4	7	**48**	8	19	8	10	5	10	1	**61**
31 to 32	1	2	3	5	3	0	3	**17**	9	14	9	11	14	8	5	**70**
33 to 35	4	7	11	14	9	9	11	**65**	40	40	35	32	45	25	34	**251**
36 to 38	18	31	9	39	22	18	28	**165**	91	73	99	87	89	85	80	**604**
39 to 41	69	57	53	113	57	73	63	**485**	204	205	201	199	195	176	165	**1345**
42 to 44	138	125	134	251	187	151	188	**1174**	450	419	479	501	430	384	423	**3086**
45 to 47	311	292	274	519	431	355	400	**2582**	732	756	779	816	734	676	707	**5200**
48 to 50	598	524	541	996	929	698	668	**4954**	1144	1209	1191	1273	1244	969	1169	**8199**
51 to 53	842	811	688	1296	1228	912	907	**6684**	1114	1171	1225	1180	1171	984	1193	**8038**
54 to 56	973	971	841	1582	1465	1063	1096	**7991**	964	1042	1054	1077	985	853	1079	**7054**
57 to 59	771	789	667	1264	1167	833	819	**6310**	530	598	554	539	545	441	646	**3853**
60 to 62	518	572	459	882	866	523	586	**4406**	269	275	269	240	286	221	293	**1853**
63 to 65	241	265	238	397	381	239	264	**2025**	128	107	106	74	104	78	134	**731**
66 to 68	112	145	87	212	174	96	123	**949**	43	42	52	37	45	30	45	**294**
69 to 147	64	91	71	145	135	69	85	**660**	28	20	27	30	32	18	26	**181**
Total	**4661**	**4691**	**4081**	**7722**	**7069**	**5043**	**5248**	**38515**	**5754**	**5990**	**6088**	**6106**	**5924**	**4958**	**6000**	**40820**
Ave Speed (mph)	**54.58**	**54.96**	**54.62**	**54.63**	**54.88**	**54.31**	**54.39**	---	**51.04**	**51.08**	**51.03**	**50.77**	**51.06**	**50.82**	**51.50**	---
Variance	**38.34**	**43.16**	**41.91**	**42.88**	**41.42**	**38.32**	**41.77**	---	**39.59**	**39.20**	**38.27**	**36.20**	**38.25**	**37.29**	**36.54**	---
Coefficient of Variance	**0.11**	**0.12**	**0.12**	**0.12**	**0.12**	**0.11**	**0.12**	---	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**	---
% Obeying Speed Limit	**56.68**	**53.61**	**56.04**	**55.84**	**54.63**	**57.76**	**57.51**	---	**77.79**	**77.96**	**78.20**	**79.87**	**78.81**	**79.23**	**75.78**	---
% Obeying Speed Limit + 5 Mph	**79.94**	**81.97**	**83.24**	**83.36**	**83.21**	**85.60**	**84.47**	---	**93.78**	**94.21**	**94.58**	**95.64**	**94.24**	**94.92**	**93.73**	---
% Obeying Speed Limit + 10 Mph	**96.22**	**94.97**	**96.13**	**95.38**	**95.63**	**96.73**	**96.04**	---	**98.77**	**98.96**	**98.70**	**98.90**	**98.70**	**99.03**	**98.82**	---
85th Percentile (mph)	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**	**60.00**	**61.00**	**---**	**57.00**	**57.00**	**57.00**	**57.00**	**57.00**	**57.00**	**57.00**	**---**

The mean decreased from 54.61 mph to 51.16 mph (difference of 3.45 mph) on weekdays (Monday to Thursday) and from 54.60 mph to 50.94 mph (difference of 3.66 mph) on weekends (Saturday and Sunday). The variance decreased from 41.29 to 38.4 (difference of 2.89) on the weekdays and from 39.87 to 37.77 (difference of 2.10 mph) on weekends. Speed limit compliance increased by 21.47% on weekdays and by 22.82 % on weekends. The 85th percentile speed did not vary from weekday to weekend and the reduction was consistently 61 mph to 57 mph. The coefficient of variation was generally unchanged for the daily data sets. From Table 5-6 it was seen that that mean and variance reduction as well as proportion increase was significant. Figure 5-7 to Figure 5-12 show clearly that the After distribution of speeds shifts to the lower speed bins as compared to the Before speeds. The shift was not as defined on the weekend as on the weekdays and this could be attributed to lower volumes and motorists' perception that speed limit enforcement is not as likely on the weekend. This coupled with the slight increase in speed limit compliance on weekends suggested that some drivers continued to speed but there was slightly greater speed limit compliance as compared to weekdays.

Table 5-6: Before and After Approach Speeds Daily Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change		Significant?						
		Weekday	Weekend	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Means	μ (b) - μ (a) > 0	-3.45	-3.66	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	-2.72	-2.10	Yes	No	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit	P (b) - P (a) < 0	21.47%	22.82%	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	11.67%	10.17%	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	2.97%	2.69%	Yes	Yes	Yes	Yes	Yes	Yes	Yes

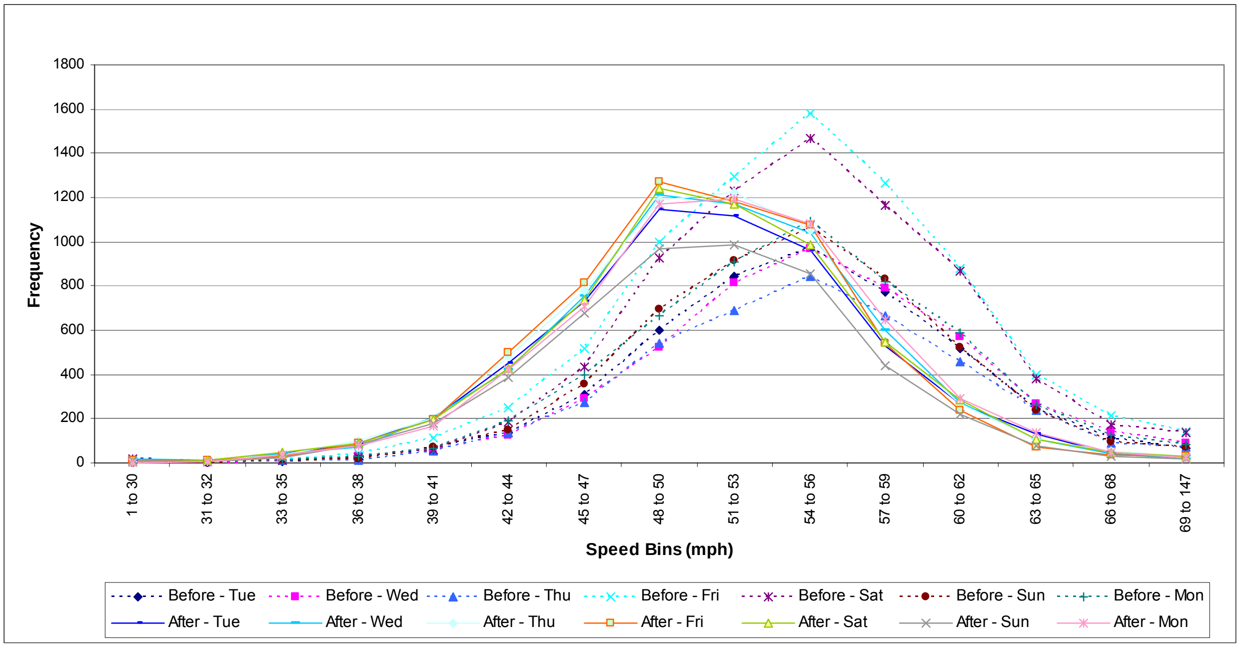


Figure 5-7: Before and After Approach Speeds Daily Frequency Graph

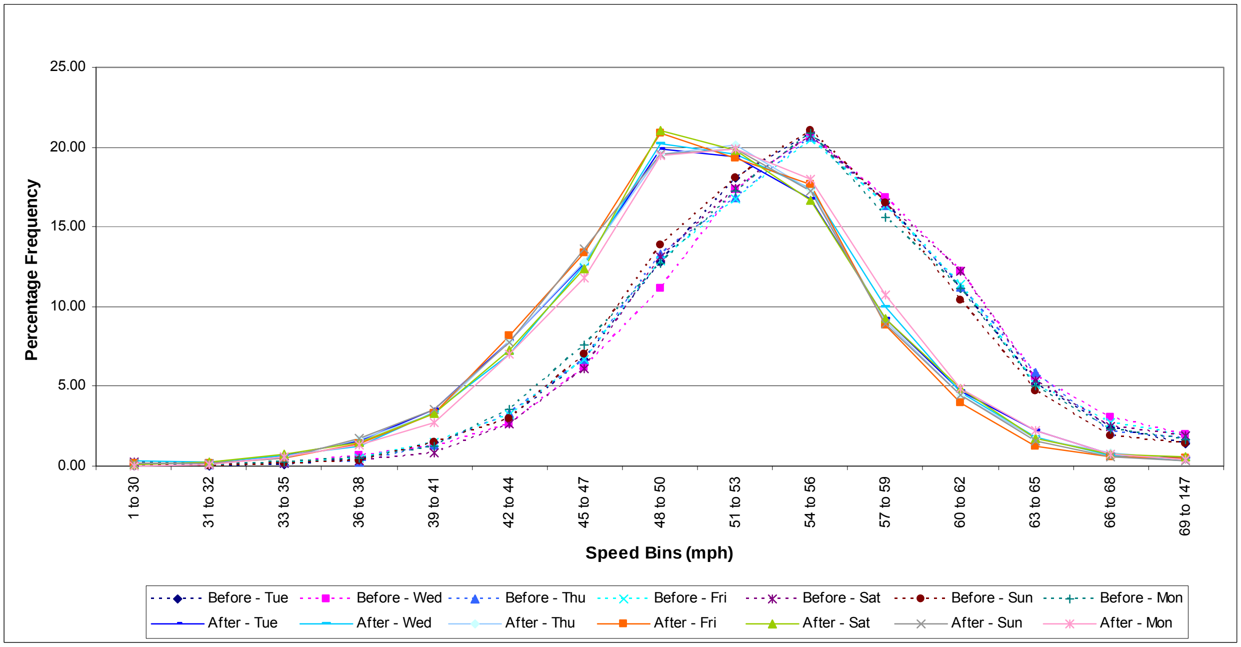


Figure 5-8: Before and After Approach Speeds Daily Percentage Frequency Graph

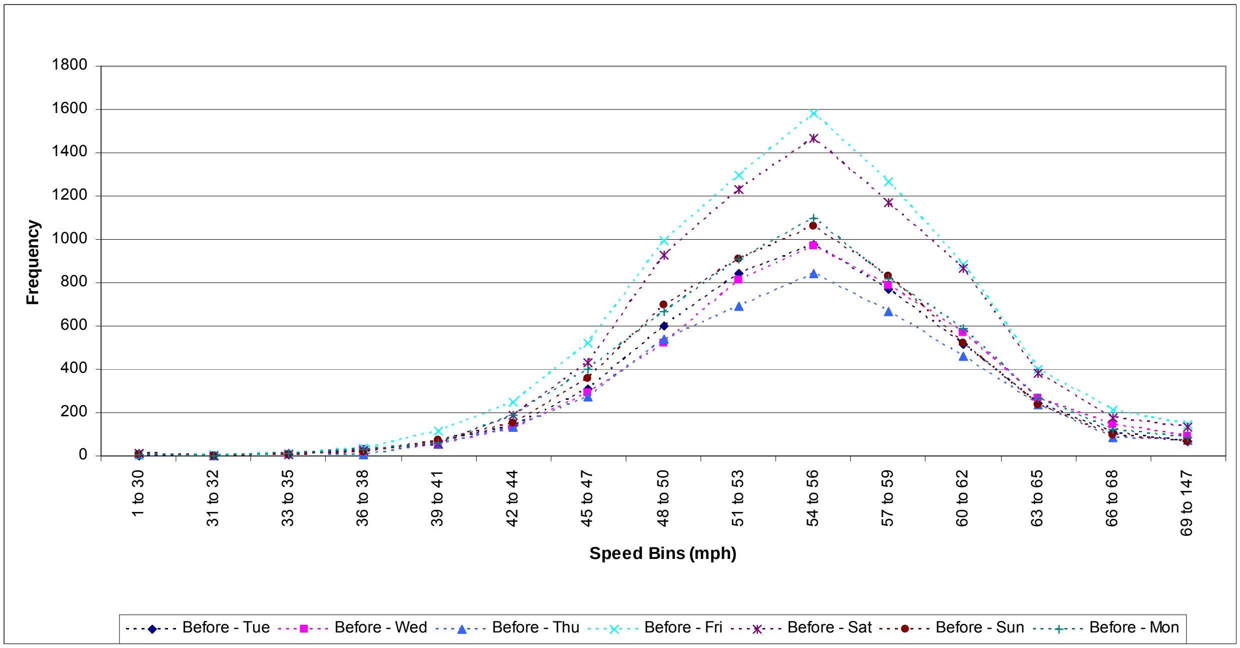


Figure 5-9: Before Approach Speeds Daily Frequency Graph

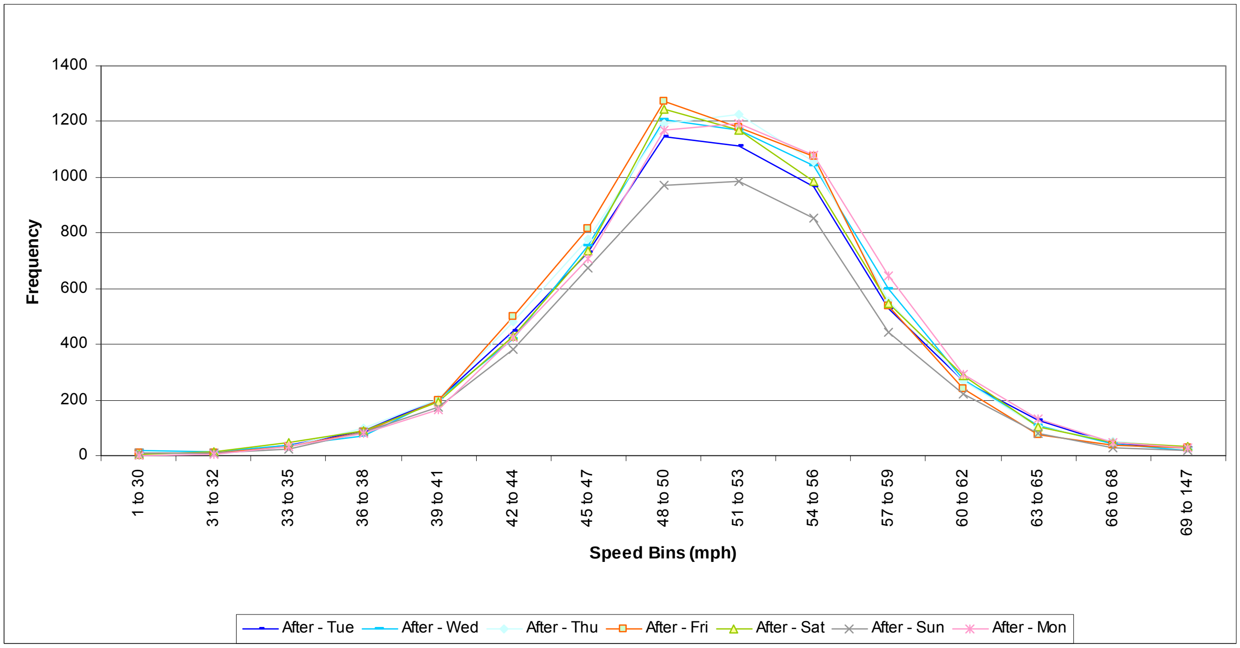


Figure 5-10: After Approach Speeds Daily Frequency Graph

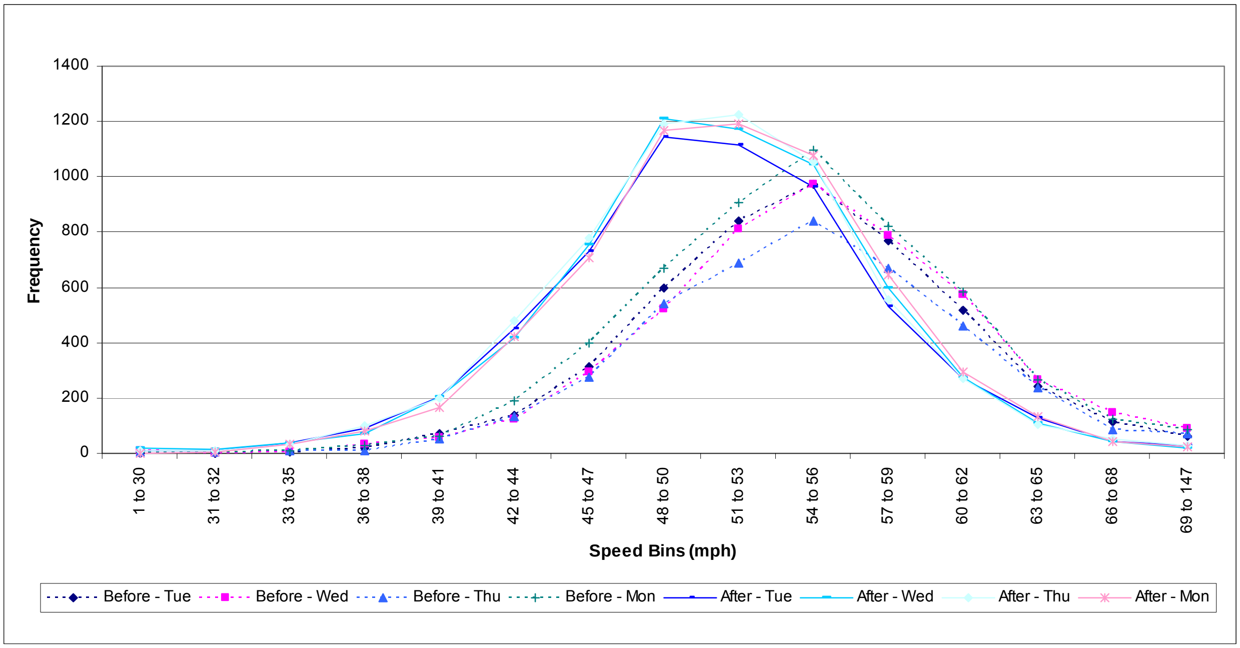


Figure 5-11: Before and After Approach Speeds Daily Weekday Frequency Graph

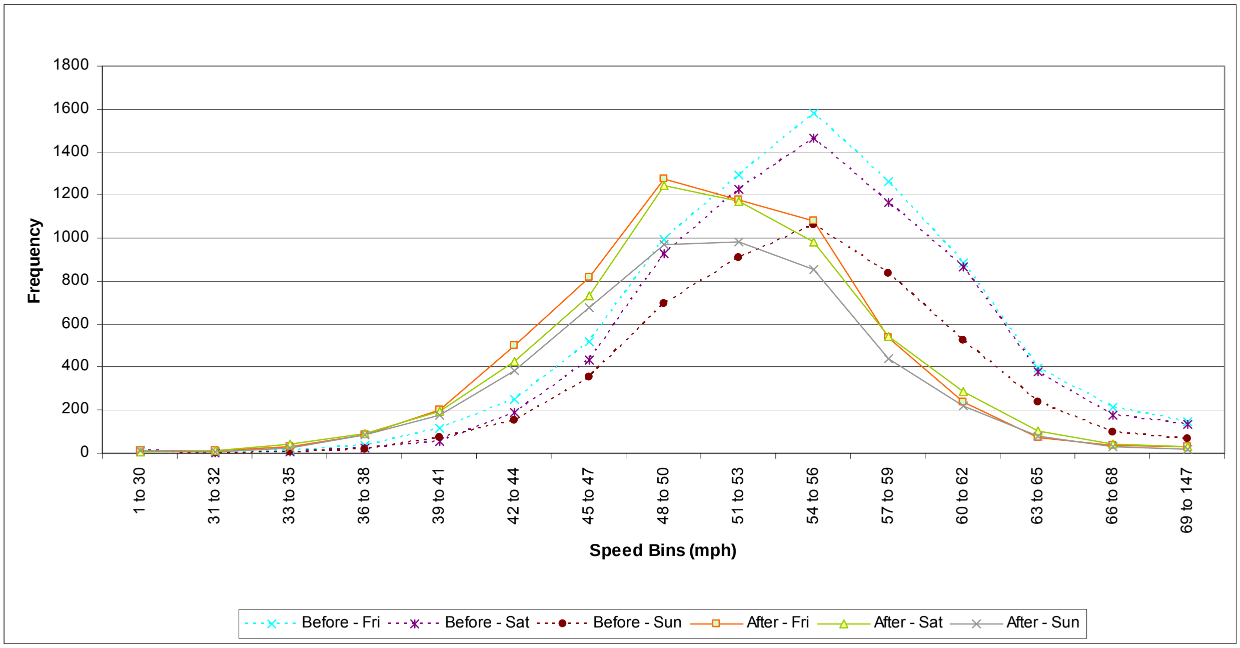


Figure 5-12: Before and After Approach Speeds Daily Weekend Frequency Graph

5.1.4 Time of Day Data Set - Before and After Approach Speeds

Table 5-7 presents the Before and After data and statistical parameters for the Approach speeds Time of Day data sets. Table 5-8 presents the summary of the hypothesis tests results. Figure 5-7 to Figure 5-12 provides frequency graphs of the Before and After speeds for the data sets.

Table 5-7: Before and After Approach Speeds TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency							Total	After TOD Vehicle Frequency							Total
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	
1 to 30	10	5	9	14	1	1	8	**48**	15	2	3	5	9	2	25	**61**
31 to 32	8	2	2	2	1	1	1	**17**	23	6	3	7	8	9	14	**70**
33 to 35	20	10	11	6	6	3	9	**65**	64	17	15	15	33	18	89	**251**
36 to 38	61	18	20	9	23	4	30	**165**	140	32	43	60	78	48	203	**604**
39 to 41	153	49	54	60	47	26	96	**485**	309	85	87	93	202	100	469	**1345**
42 to 44	281	102	129	120	136	89	317	**1174**	589	196	265	282	399	273	1082	**3086**
45 to 47	558	181	295	240	335	202	771	**2582**	893	304	434	465	770	524	1810	**5200**
48 to 50	1025	349	431	472	632	410	1635	**4954**	1318	518	710	801	1220	856	2776	**8199**
51 to 53	1294	494	606	604	951	634	2101	**6684**	1264	548	720	805	1315	876	2510	**8038**
54 to 56	1427	600	722	636	1162	869	2575	**7991**	1047	606	691	748	1231	776	1955	**7054**
57 to 59	1030	529	535	597	1002	724	1893	**6310**	601	336	344	416	754	422	980	**3853**
60 to 62	695	381	348	415	782	564	1221	**4406**	319	195	165	205	345	199	425	**1853**
63 to 65	301	199	172	173	333	281	566	**2025**	147	81	68	86	144	61	144	**731**
66 to 68	141	108	97	84	187	113	219	**949**	50	38	21	43	48	29	65	**294**
69 to 147	99	77	47	63	107	84	183	**660**	48	29	11	17	32	12	32	**181**
Total	**7103**	**3104**	**3478**	**3495**	**5705**	**4005**	**11625**	**38515**	**6827**	**2993**	**3580**	**4048**	**6588**	**4205**	**12579**	**40820**
Ave Speed (mph)	**53.69**	**55.09**	**54.10**	**54.39**	**55.38**	**55.78**	**54.55**	**---**	**50.62**	**52.24**	**51.35**	**51.57**	**51.68**	**51.38**	**50.31**	**---**
Variance	**43.47**	**46.63**	**43.91**	**48.28**	**38.77**	**36.70**	**37.04**	—	**44.33**	**43.04**	**34.75**	**37.52**	**37.02**	**33.14**	**35.10**	—
Coefficient of Variance	**0.12**	**0.12**	**0.12**	**0.13**	**0.11**	**0.11**	**0.11**	—	**0.13**	**0.13**	**0.11**	**0.12**	**0.12**	**0.11**	**0.12**	—
% Obeying Speed Limit	**61.79**	**52.32**	**58.77**	**55.51**	**51.06**	**48.51**	**57.60**	—	**78.57**	**71.07**	**77.99**	**75.99**	**74.57**	**77.34**	**82.71**	—
% Obeying Speed Limit + 5 Mph	**86.64**	**80.61**	**84.91**	**83.58**	**80.72**	**79.38**	**85.50**	—	**93.89**	**91.25**	**94.39**	**93.33**	**93.66**	**94.93**	**96.11**	—
% Obeying Speed Limit + 10 Mph	**96.62**	**94.04**	**95.86**	**95.79**	**94.85**	**95.08**	**96.54**	—	**98.56**	**97.76**	**99.11**	**98.52**	**98.79**	**99.02**	**99.23**	—
85th Percentile (mph)	**60.00**	**62.00**	**61.00**	**61.00**	**61.00**	**62.00**	**60.00**	**---**	**57.00**	**59.00**	**57.00**	**57.00**	**58.00**	**57.00**	**56.00**	**---**

Table 5-8: Before and After Approach Speeds TOD Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	No	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes

From Table 5-8 it can be seen that generally both the speed mean and variance reduction was significant. During the 12 AM to 7 AM time period the variance was not significantly reduced and examination of the speed data indicated that there was a larger number of vehicles in the higher speed bins as compared to the other days. This indicated that during the late night and early morning, when traffic volumes are less, some motorists traveled at higher speeds and were not as likely to be affected by the DSM system. Speed limit compliance and reduction in the proportion of vehicles in the higher speed ranges was seen to be significant. Speed limit compliance generally increased by approximately 20% with the largest increase occurring between the 6:00 PM to 12 AM time period (26%). The 85th percentile speed was generally reduced from 61 mph to 57 mph, and the coefficient of variation was approximately unchanged. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds. This is consistent with the trend seen thus far.

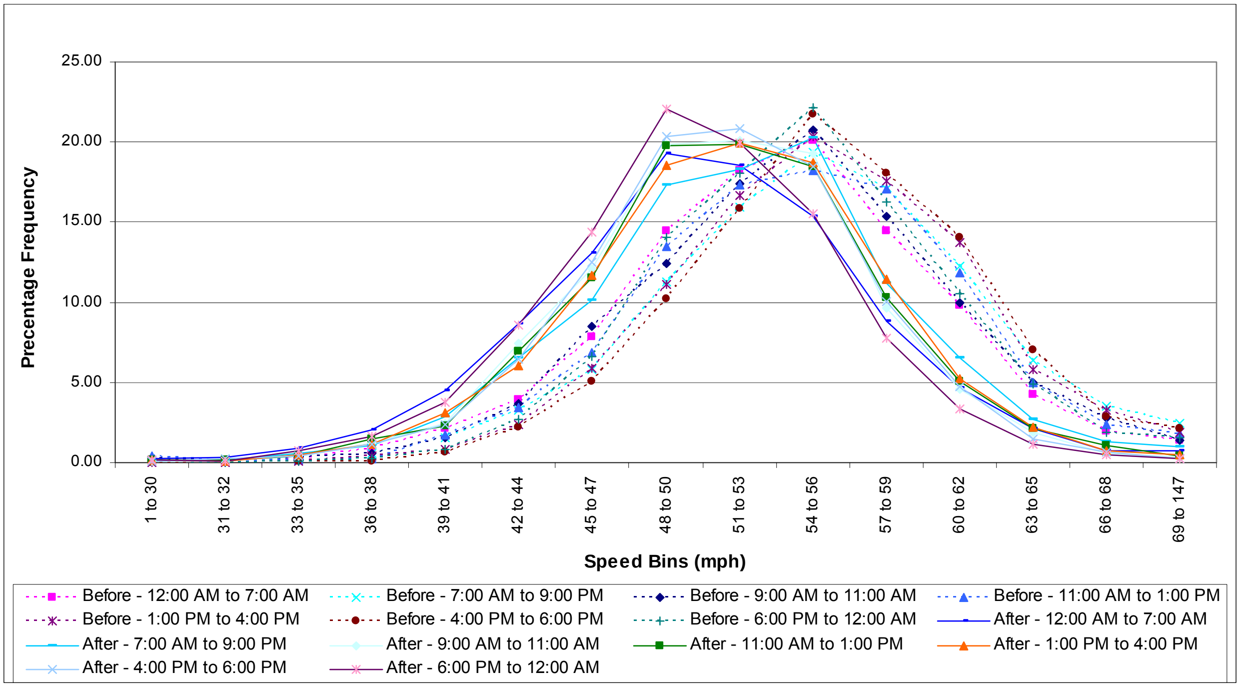


Figure 5-13: Before and After Approach Speeds TOD Percentage Frequency Graph

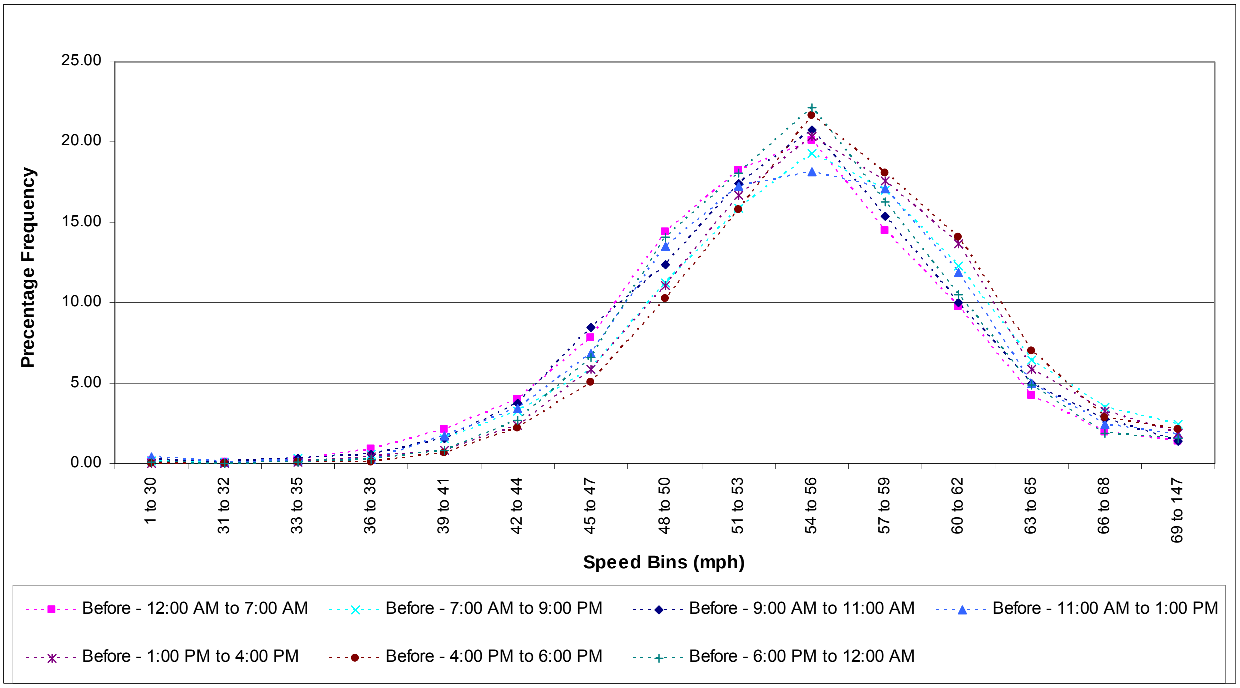


Figure 5-14: Before Approach Speeds TOD Percentage Frequency Graph

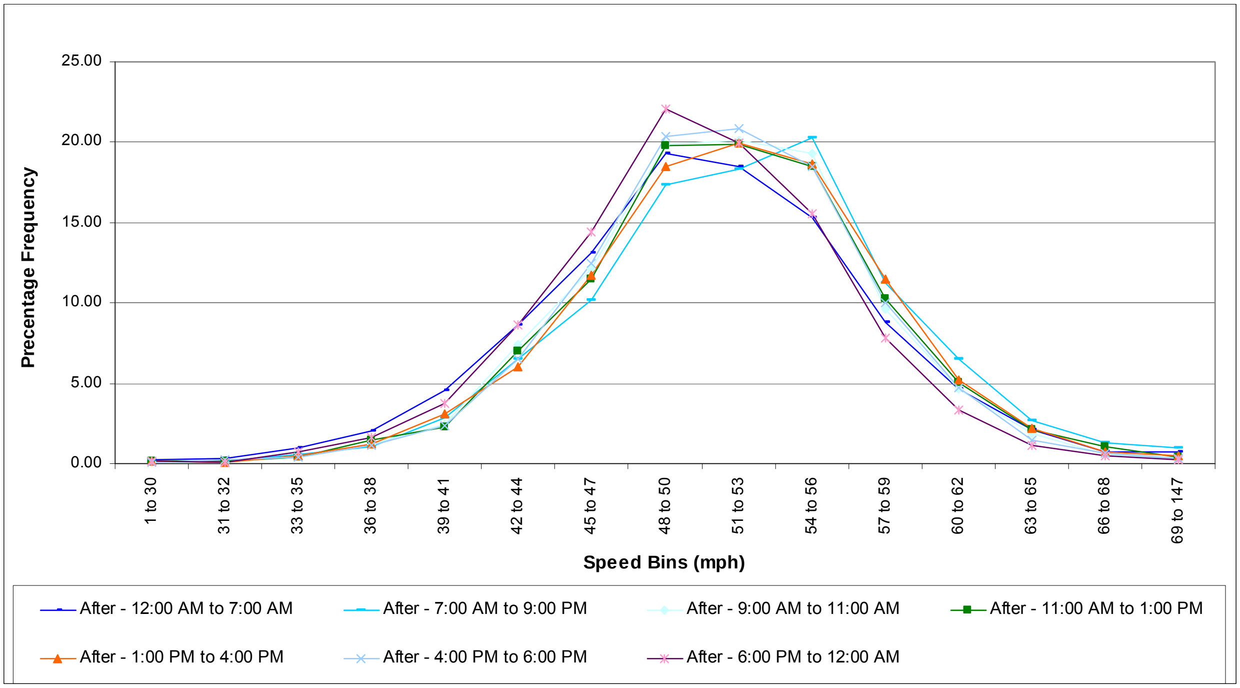


Figure 5-15: After Approach Speeds TOD Percentage Frequency Graph

5.1.5 Weekday TOD Data Set - Before and After Approach Speeds

Table 5-9 presents the Before and After data and statistical parameters for the Approach speeds Weekday Time of Day data sets. Table 5-10 presents the summary of the hypothesis tests results. Figure 5-16 to Figure 5-18 provides frequency graphs of the Before and After speeds for the data sets.

From Table 5-10 it can be seen that the both the speed mean and variance reduction was generally significant. During the 6 PM to 12 AM time period the variance was not significantly reduced, however the difference between variance was very small and examination of the speed data indicated that there was a larger number of vehicles in the lower speed bins as compared to the other days. This could possibly be due to the congestion related to larger volume weekday evening traffic that is associated with the nearby tourist attractions along US 192. In addition, speed limit compliance and reduction in the proportion of vehicles in the higher speed ranges was seen to be significant. Speed limit compliance generally increased by approximately 20% with the largest increase occurring between the 6 PM to 12 AM time period (24%). The 85th percentile speed was generally reduced from 61 mph to 58 mph, and the coefficient of variation was approximately unchanged. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds.

Table 5-9: Before and After Approach Speeds Weekday TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency								After TOD Vehicle Frequency							
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total
1 to 30	4	4	4	4	1	1	4	**22**	6	2	3	1	6	0	18	**36**
31 to 32	5	1	0	1	1	1	0	**9**	6	3	2	5	6	6	9	**37**
33 to 35	12	7	4	4	0	1	5	**33**	34	9	8	10	25	9	54	**149**
36 to 38	34	9	9	5	12	3	14	**86**	78	18	31	37	50	20	109	**343**
39 to 41	86	21	19	30	26	10	50	**242**	174	54	45	52	138	46	266	**775**
42 to 44	135	48	60	61	62	43	176	**585**	392	117	157	162	232	143	568	**1771**
45 to 47	269	85	145	119	154	93	411	**1276**	559	189	249	269	414	296	998	**2974**
48 to 50	453	161	177	191	266	200	883	**2331**	841	300	409	448	671	488	1556	**4713**
51 to 53	567	241	254	274	443	308	1161	**3248**	788	336	421	455	747	501	1455	**4703**
54 to 56	668	271	325	256	521	441	1399	**3881**	648	399	418	445	689	434	1106	**4139**
57 to 59	461	255	246	246	429	350	1059	**3046**	369	218	225	251	419	242	604	**2328**
60 to 62	320	208	165	155	347	257	683	**2135**	190	122	104	121	195	118	256	**1106**
63 to 65	129	104	73	78	151	143	330	**1008**	96	51	47	52	95	36	98	**475**
66 to 68	63	52	45	42	88	59	118	**467**	28	27	12	28	35	16	36	**182**
69 to 147	48	34	21	30	42	39	97	**311**	23	19	9	11	16	5	18	**101**
Total	**3254**	**1501**	**1547**	**1496**	**2543**	**1949**	**6390**	18680	**4232**	**1864**	**2140**	**2347**	**3738**	**2360**	**7151**	**23832**
Ave Speed (mph)	**53.53**	**55.20**	**54.23**	**54.19**	**55.32**	**55.77**	**54.63**	---	**50.66**	**52.45**	**51.53**	**51.70**	**51.62**	**51.54**	**50.47**	---
Variance	**45.19**	**48.67**	**43.30**	**49.39**	**39.59**	**36.19**	**36.21**	---	**40.91**	**44.17**	**36.97**	**37.70**	**39.57**	**31.73**	**36.40**	---
Coefficient of Variance	**0.13**	**0.13**	**0.12**	**0.13**	**0.11**	**0.11**	**0.11**	---	**0.13**	**0.13**	**0.12**	**0.12**	**0.12**	**0.11**	**0.12**	---
% Obeying Speed Limit	**62.14**	**50.57**	**57.34**	**57.69**	**51.75**	**49.36**	**57.15**	---	**78.97**	**70.12**	**75.98**	**74.78**	**74.40**	**76.99**	**81.47**	---
% Obeying Speed Limit + 5 Mph	**86.85**	**79.88**	**84.42**	**83.02**	**80.77**	**78.96**	**85.29**	---	**94.09**	**91.04**	**94.02**	**92.67**	**92.96**	**94.70**	**95.72**	---
% Obeying Speed Limit + 10 Mph	**96.59**	**94.27**	**95.73**	**95.19**	**94.89**	**94.97**	**96.64**	---	**98.79**	**97.53**	**99.02**	**98.34**	**98.64**	**99.11**	**99.24**	---
85th Percentile (mph)	**60.00**	**62.00**	**61.00**	**61.00**	**61.00**	**62.00**	**60.00**	---	**57.00**	**59.00**	**57.00**	**58.00**	**58.00**	**57.00**	**56.00**	---

Table 5-10: Before and After Approach Speeds TOD Weekday Data Set Hypothesis Tests

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	No
% Obeying Speed Limit	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes

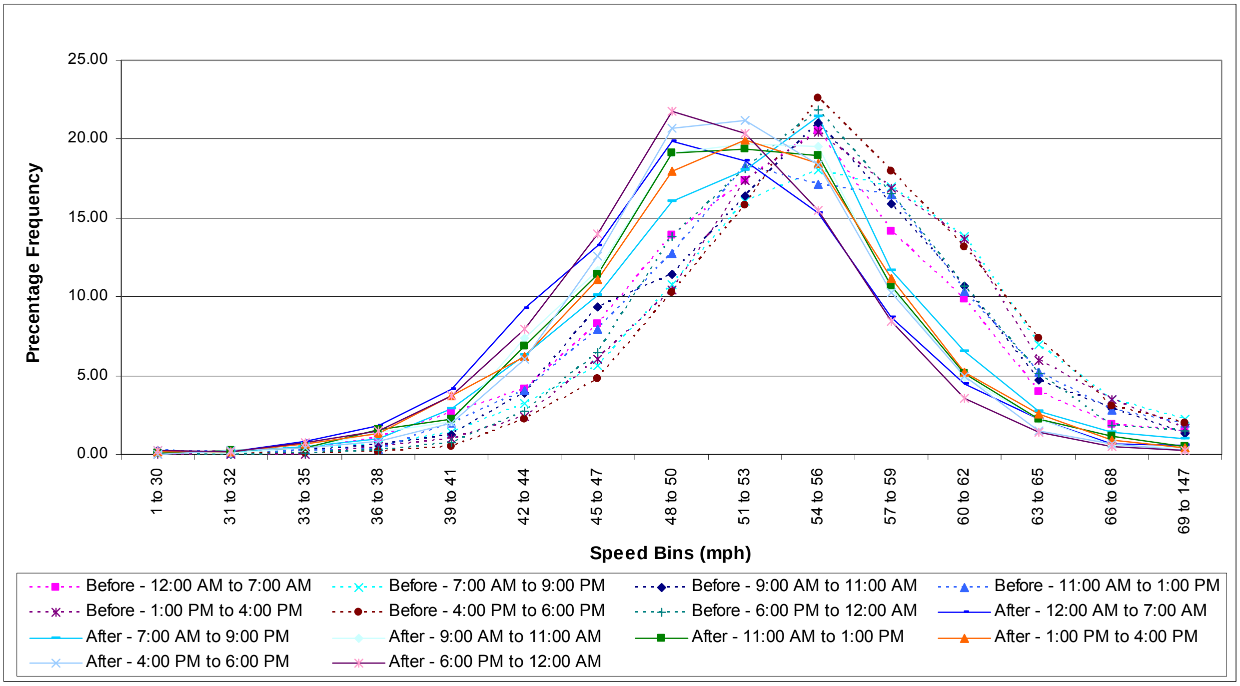


Figure 5-16: Before & After Approach Speeds Wkday TOD Percentage Frequency Graph

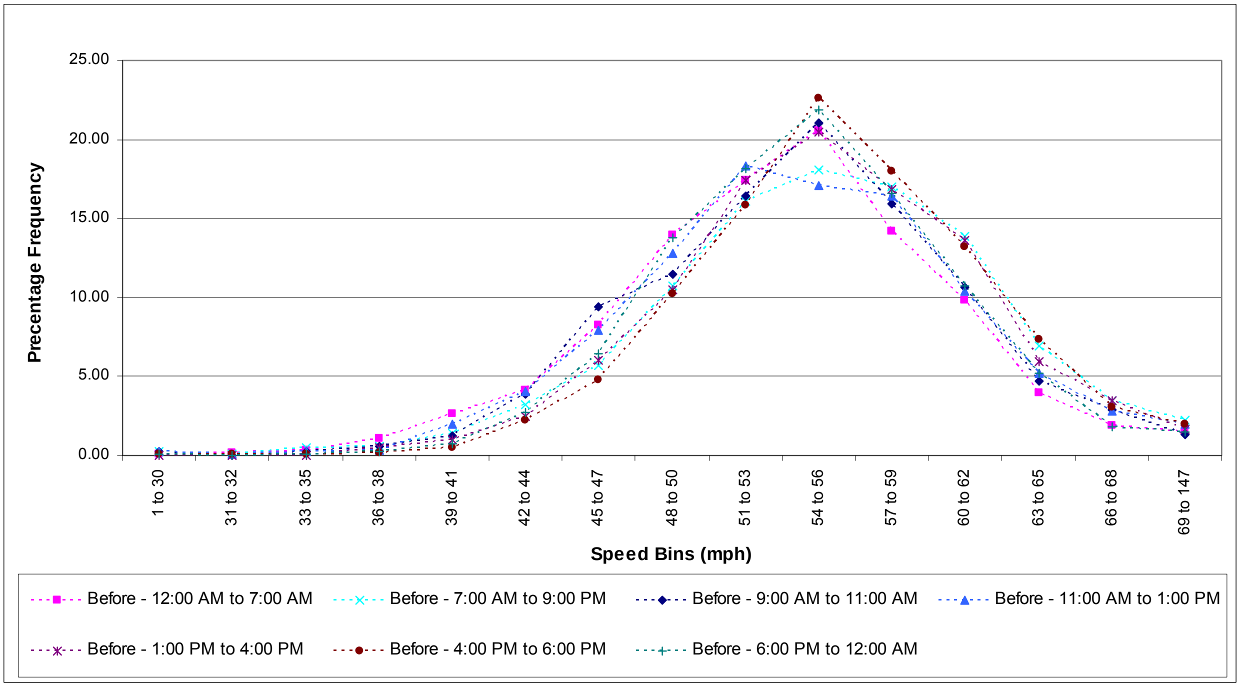


Figure 5-17: Before Approach Speeds Wkday TOD Percentage Frequency Graph

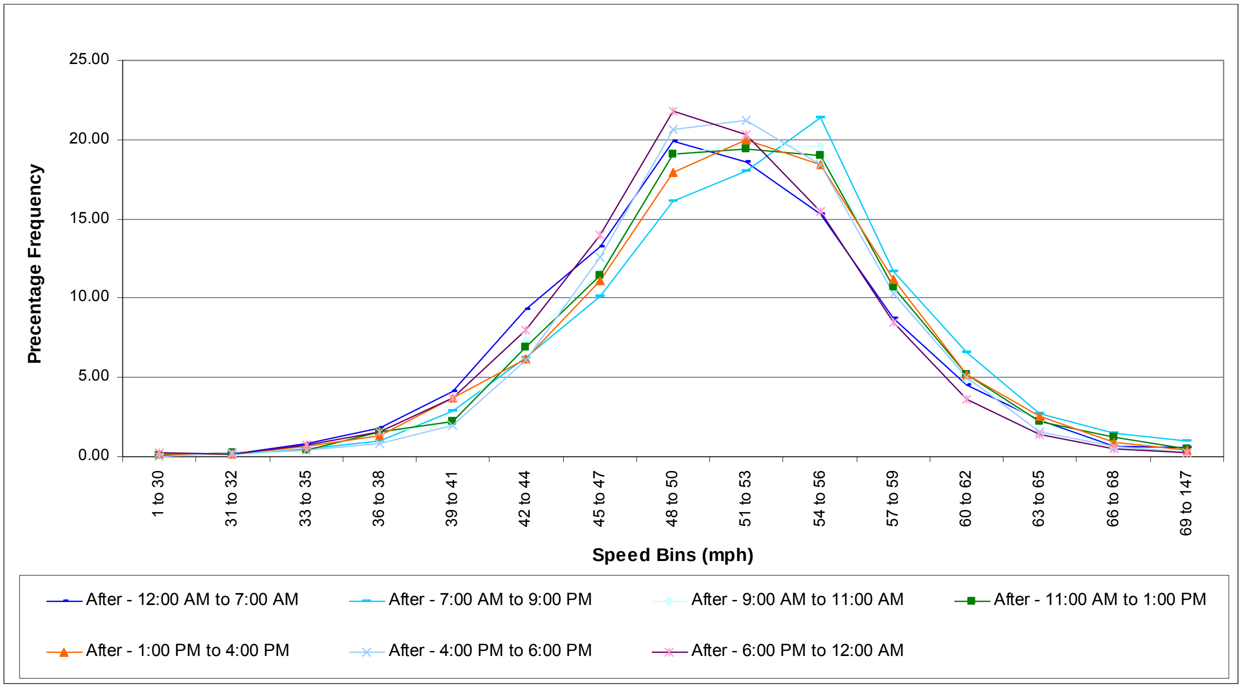


Figure 5-18: After Approach Speeds Wkday TOD Percentage Frequency Graph

5.1.6 Weekend TOD Data Set - Before and After Approach Speeds

Table 5-11 presents the Before and After data and statistical parameters for the Approach speeds Weekend Time of Day data sets. Table 5-12 presents the summary of the hypothesis tests results. Figure 5-19 to Figure 5-21 provides frequency graphs of the Before and After speeds for the data sets.

As with the Time of Day data set, during the 12 AM to 7 AM time period the variance was not significantly reduced. This again indicated that on weekends during the late night and early morning, when weekend traffic volumes are less, some motorists traveled at higher speeds and were not as likely to be affect by the DSM system. Speed limit compliance and reduction in the proportion of vehicles in the higher speed ranges was also seen to be significant. Speed limit compliance generally increased by approximately 20% with the largest increase occurring between the 6 PM to 12 AM time period (28%). The 85th percentile speed was generally reduced from 61 mph to 57 mph, and the coefficient of variation was unchanged. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds and this is consistent with the trend previously seen.

Table 5-11: Before and After Approach Speeds Weekend TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency								After TOD Vehicle Frequency							
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total
1 to 30	5	1	4	8	0	0	1	**19**	6	0	0	3	3	0	3	**15**
31 to 32	1	1	0	1	0	0	0	**3**	13	1	1	2	1	1	3	**22**
33 to 35	4	2	4	1	3	1	3	**18**	21	6	5	3	6	4	25	**70**
36 to 38	17	4	5	1	3	0	10	**40**	36	6	8	17	18	17	72	**174**
39 to 41	34	15	15	14	11	13	28	**130**	77	21	26	22	44	32	149	**371**
42 to 44	76	33	42	32	42	32	81	**338**	108	37	68	80	112	72	337	**814**
45 to 47	153	56	97	81	116	69	214	**786**	206	70	107	114	221	144	548	**1410**
48 to 50	346	113	147	193	242	121	465	**1627**	261	122	189	231	355	235	820	**2213**
51 to 53	441	151	228	215	337	216	552	**2140**	261	117	176	234	406	260	701	**2155**
54 to 56	495	190	253	254	415	263	658	**2528**	208	122	159	201	354	226	568	**1838**
57 to 59	367	163	178	213	348	245	486	**2000**	132	74	65	100	241	131	243	**986**
60 to 62	213	105	109	159	280	192	331	**1389**	87	44	40	53	105	61	117	**507**
63 to 65	112	45	66	60	109	88	140	**620**	34	18	16	26	35	22	31	**182**
66 to 68	45	30	31	23	58	30	53	**270**	16	8	5	8	8	11	19	**75**
69 to 147	34	23	12	17	40	34	44	**204**	11	7	2	4	10	7	9	**50**
Total	**2343**	**932**	**1191**	**1272**	**2004**	**1304**	**3066**	**12112**	**1477**	**653**	**867**	**1098**	**1919**	**1223**	**3645**	**10882**
Ave Speed (mph)	**54.06**	**54.79**	**54.05**	**54.35**	**55.40**	**55.81**	**54.39**	**---**	**50.49**	**52.18**	**51.04**	**51.41**	**51.88**	**51.70**	**50.02**	**---**
Variance	**41.42**	**43.14**	**43.06**	**46.54**	**36.75**	**38.13**	**36.42**	---	**52.81**	**42.87**	**32.99**	**36.81**	**33.80**	**34.72**	**33.59**	---
Coefficient of Variance	**0.12**	**0.12**	**0.12**	**0.13**	**0.11**	**0.11**	**0.11**	---	**0.14**	**0.13**	**0.11**	**0.12**	**0.11**	**0.11**	**0.12**	---
% Obeying Speed Limit	**60.65**	**54.83**	**60.20**	**55.42**	**50.95**	**47.70**	**57.99**	---	**77.18**	**70.90**	**81.08**	**78.14**	**73.84**	**75.39**	**84.88**	---
% Obeying Speed Limit + 5 Mph	**86.34**	**82.62**	**85.81**	**84.98**	**81.29**	**79.98**	**85.81**	---	**92.62**	**90.35**	**94.23**	**94.08**	**94.37**	**93.95**	**96.60**	---
% Obeying Speed Limit + 10 Mph	**96.63**	**94.31**	**96.39**	**96.86**	**95.11**	**95.09**	**96.84**	---	**98.17**	**97.70**	**99.19**	**98.91**	**99.06**	**98.53**	**99.23**	---
85th Percentile (mph)	**60.00**	**61.00**	**60.00**	**60.35**	**61.00**	**62.00**	**60.00**	---	**58.00**	**59.00**	**56.00**	**57.00**	**58.00**	**57.00**	**56.00**	---

Table 5-12: Before and After Approach Speeds Weekend TOD Data Hypothesis Tests

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	No	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 5 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Speed Limit + 10 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes

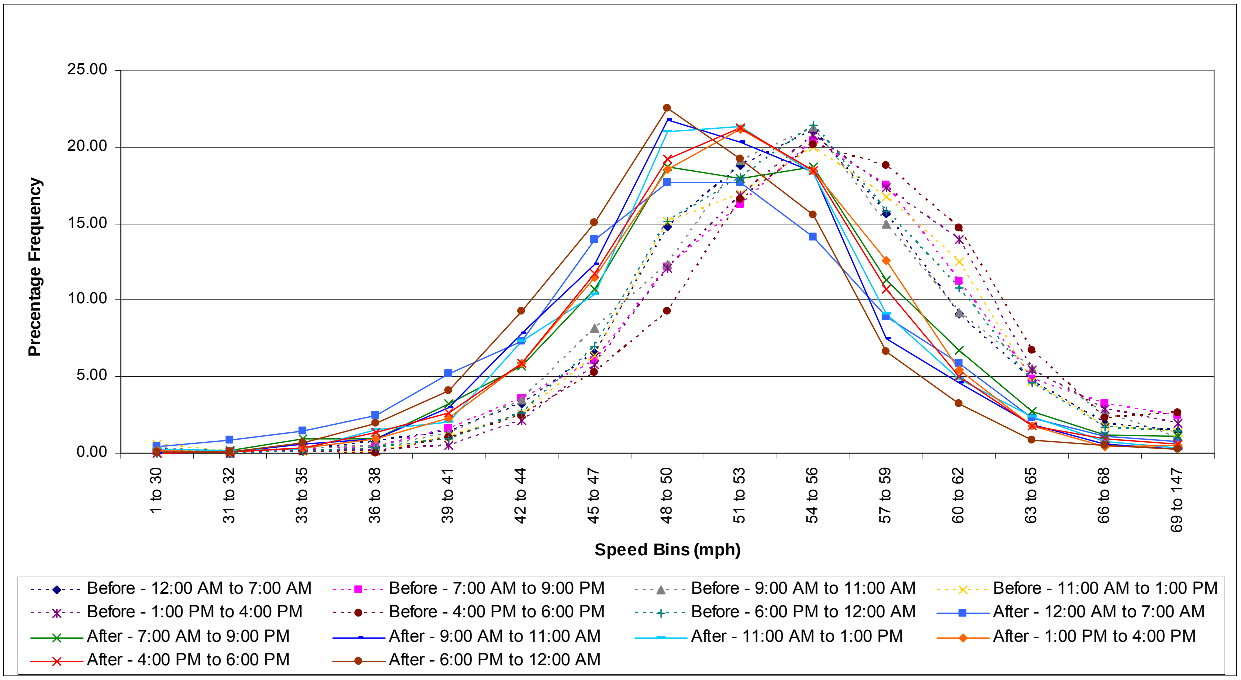


Figure 5-19: Before & After Approach Speeds Wkend TOD Percentage Frequency Graph

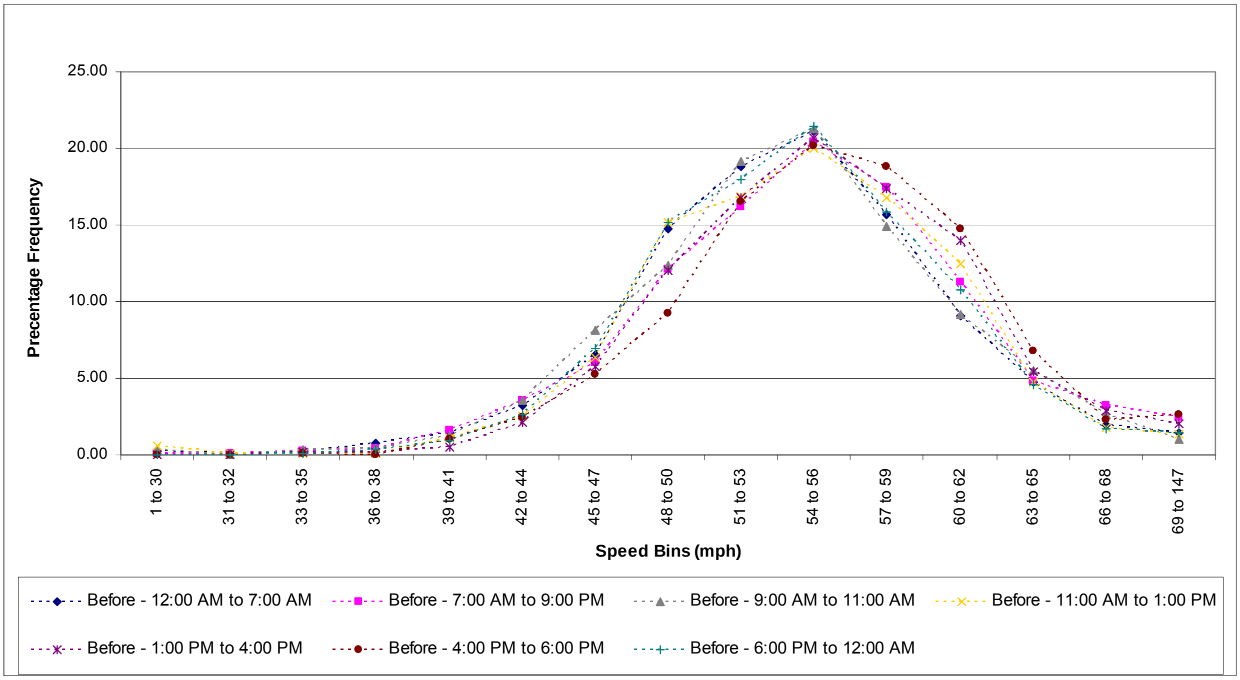


Figure 5-20: Before Approach Speeds Wkend TOD Percentage Frequency Graph

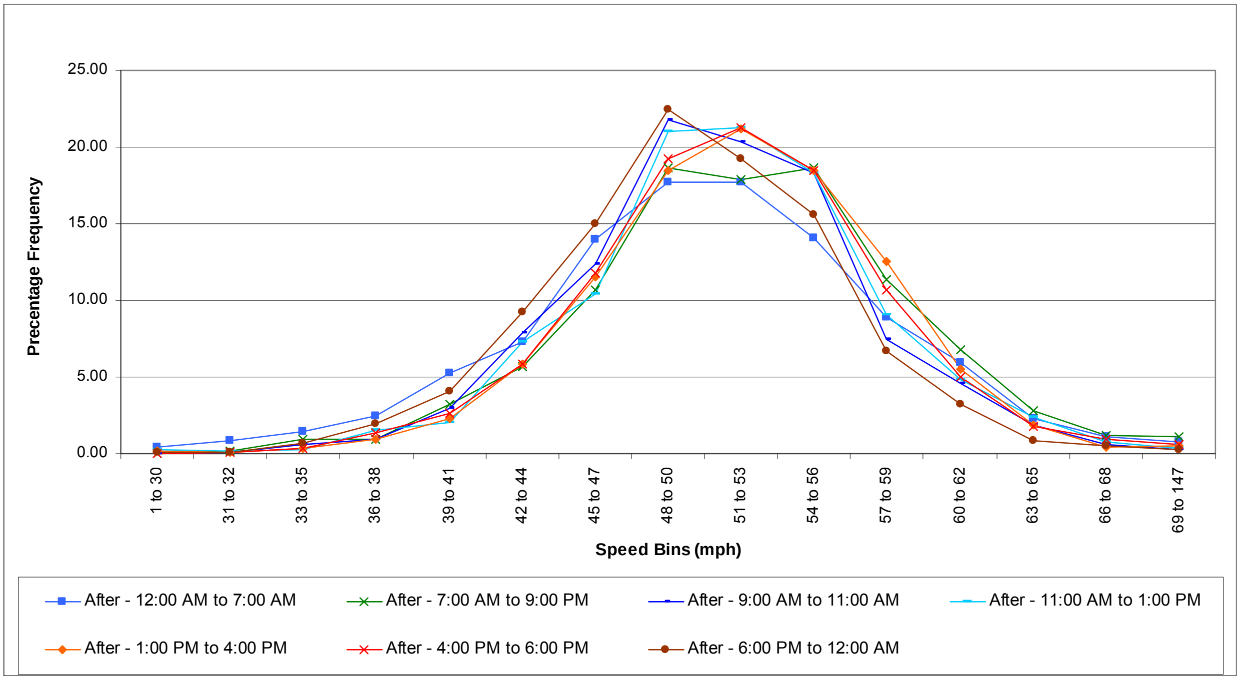


Figure 5-21: After Approach Speeds Wkend TOD Percentage Frequency Graph

5.1.7 Speed Range Data Set - Before and After Approach Speeds

Table 5-13 presents the Before and After data and statistical parameters for the Speed Range Approach data sets. Table 5-14 presents the hypothesis tests results. Figure 5-22 and Figure 5-23 illustrate graphically the variation in the Before and After frequency and means respectively.

Table 5-13 shows that generally the speed mean reduction was significant except for the 1 to 35 mph and 36 to 47 mph ranges. The mean speed in the 1-35 speed range was not significantly reduced because vehicles, originally traveling in the higher speed bins, were slowing down to within the 1 to 35 speed range thus causing this increase in mean speed. The speed variance in the 36 to 47 mph speed range was not significantly reduced potentially because as the distribution of all the speeds shifted to the lower speed bins there were more vehicles traveling at the lower and upper speeds of this speed range.

Table 5-13: Before & After Approach Speeds Speed Ranges Data Set Summary

Parameters	Speed Ranges Bins				
	1 to 35	36 to 47	48 to 59	60 to 147	Total
BEFORE					
Frequency	130	4406	25939	8040	38515
Average Speed (mph)	28.09	44.37	53.83	63.28	---
Variance	77.46	6.60	10.30	13.78	---
Coefficient of Variance	0.31	0.06	0.06	0.06	---
Proportion	0.003	0.114	0.673	0.209	1.000
AFTER					
Frequency	382	10235	27144	3059	40820
Average Speed (mph)	32.22	43.88	52.69	62.80	---
Variance	19.03	7.73	9.95	11.42	---
Coefficient of Variance	0.14	0.06	0.06	0.05	---
Proportion	0.009	0.251	0.665	0.075	1.000

Table 5-14: Before & After Approach Speeds Speed Ranges Data Hypothesis Tests

Hypothesis Test	Alternate Hypothesis	Significant?			
		1 to 35	36 to 47	48 to 59	60 to 147
Means	μ (b) - μ (a) > 0	No	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	No	Yes	Yes
Lower Speed Range Proportion	P (b) - P (a) < 0	Yes	Yes	---	---
Higher Speed Range Proportion	P (b) - P (a) > 0	---	---	Yes	Yes

It can also be seen that the increase in proportion of vehicles in the lower speed ranges and the decrease in proportion of vehicles in the upper speed ranges was significant. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds. More vehicles traveled in the lower speed ranges and less traveled in the upper speed ranges as shown in Figure 5-22.

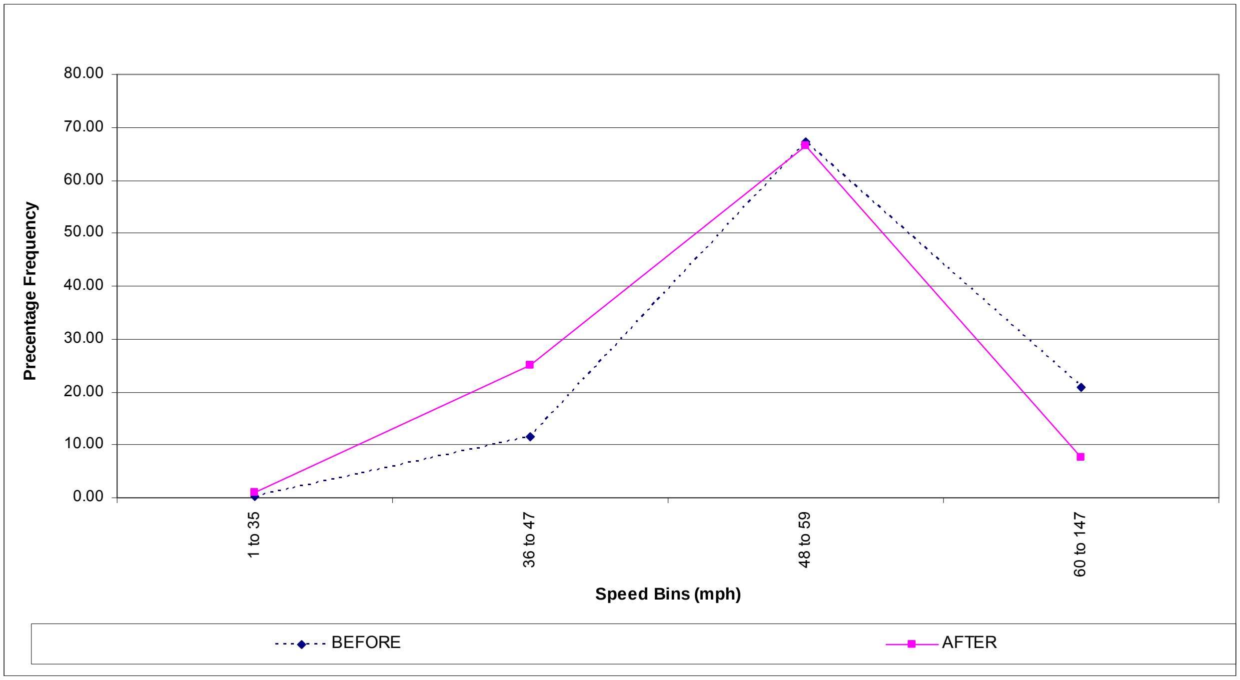


Figure 5-22: Before & After Approach Speed Ranges Percentage Frequency Graph

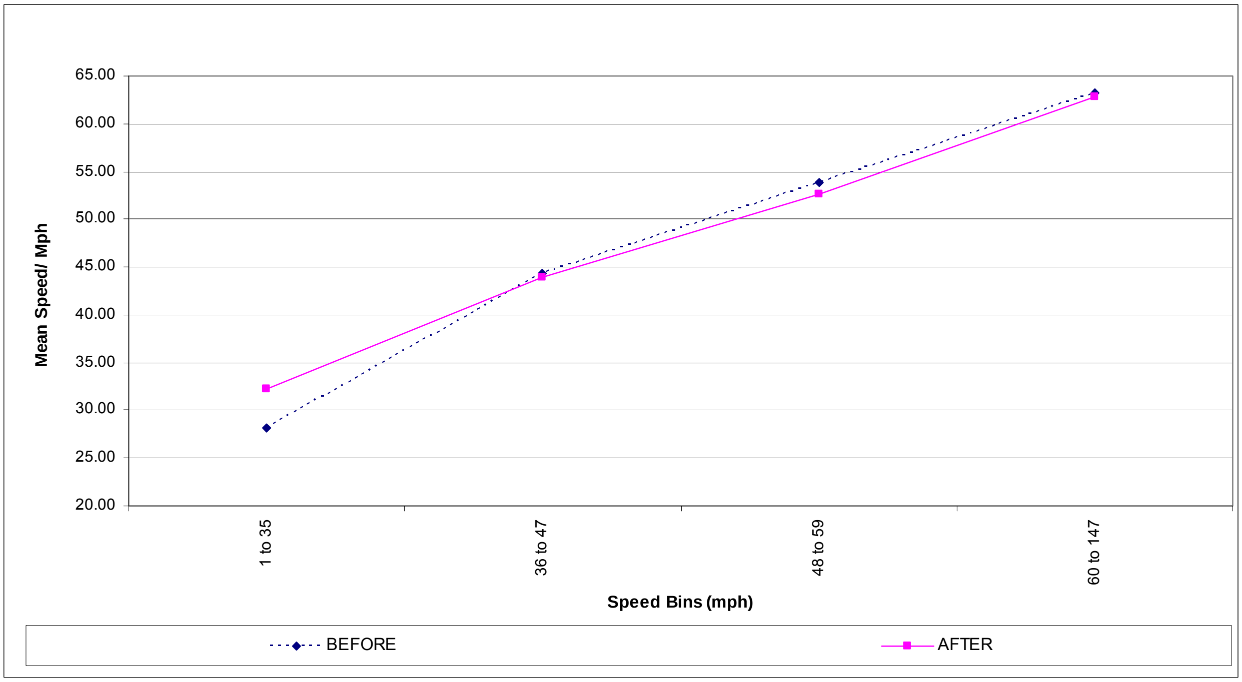


Figure 5-23: Before & After Approach Speed Ranges Mean Graph

5.1.8 Higher Speed Range Data Set - Before and After Approach Speeds

Table 5-15 presents the speed data for the higher speed ranges (57 mph and greater) of the Approach data set. The table shows the percentage reduction in the proportion of vehicles in the higher speed ranges was 42% or greater. As the speed range increased the reduction percentage also increased as shown in Figure 5-24. Figure 5-26 shows the before and after proportion of vehicles in the higher speed ranges and illustrates visually the reduction.

Table 5-15: Before & After Approach Higher Speed Ranges Data Set Summary

Speed Bins (> 57 mph only)	Before		After		Percentage Reduction in Proportion of Vehicles in Speed Range
	Percentage of Total Data Collected	Frequency	Percentage of Total Data Collected	Frequency	
57 to 59	16.383	6310	9.439	3853	42.4%
60 to 62	11.440	4406	4.539	1853	60.3%
63 to 65	5.258	2025	1.791	731	65.9%
66 to 68	2.464	949	0.720	294	70.8%
69 to 147	1.714	660	0.443	181	74.1%

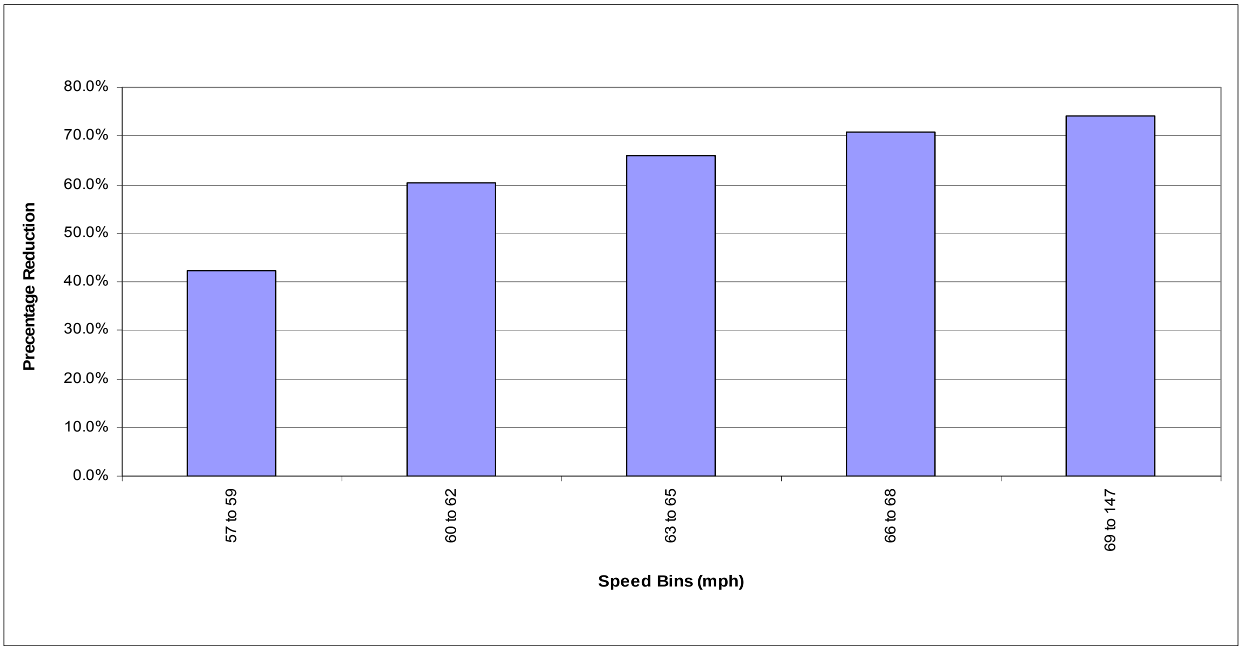
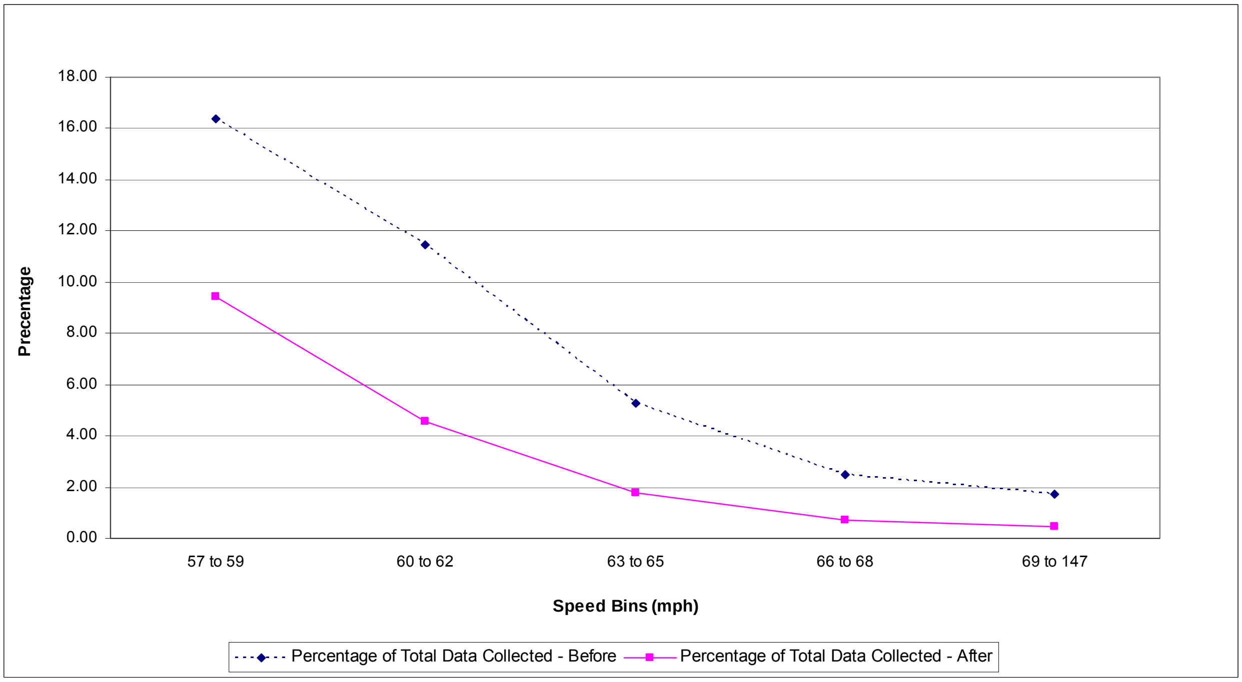


Figure 5-24: Before & After Approach Speeds - Percentage Reduction in Proportion of Vehicles in Higher Speed Ranges



5-25: Before and After Approach Speeds Percentage of Vehicles in Higher Speed Ranges

5.2 Before and After PC Speed Data

5.2.1 Entire Data Set – Before and After PC Speeds

Table 5-16 presents the Before and After data and statistical parameters for the PC speeds Entire data set. Table 5-17 presents the summary of the hypothesis tests results. Figure 5-26 provides a frequency graph and Figure 5-27 provides a cumulative frequency graph.

Table 5-16 shows that the mean decreased by 1.57 mph and the variance by 0.70. Advisory speed compliance increased by only 3.94 %, however compliance with the advisory speed + 5 mph and advisory speed + 10 mph increased by 11.56% and 11.75% respectively.

Table 5-16: Before and After PC Speeds Entire Data Set Summary

Speed Bins (mph)	Before Vehicle Frequency		After Vehicle Frequency	
	Percentage of Total	Frequency	Percentage of Total	Frequency
1 to 30	0.008	449	0.009	547
31 to 32	0.008	473	0.016	919
33 to 35	0.035	2055	0.065	3842
36 to 38	0.086	5031	0.125	7346
39 to 41	0.156	9152	0.193	11372
42 to 44	0.248	14551	0.250	14711
45 to 47	0.193	11348	0.166	9766
48 to 50	0.152	8913	0.108	6386
51 to 53	0.080	4681	0.050	2947
54 to 56	0.023	1347	0.012	720
57 to 59	0.008	482	0.004	236
60 to 147	0.003	197	0.002	89
Total	**---**	**58679**	**---**	**58881**
Average Speed (mph)	**---**	**44.15**	**---**	**42.58**
Variance	**---**	**29.92**	**---**	**29.22**
Coefficient of Variance	**---**	**0.12**	**---**	**0.13**
% Obeying Advisory Speed	**---**	**5.07**	**---**	**9.01**
% Obeying Advisory Speed + 5Mph	**---**	**29.24**	**---**	**40.80**
% Obeying Advisory Speed + 10 Mph	**---**	**54.04**	**---**	**65.79**
85th Percentile (mph)	**---**	**47.00**	**---**	**46.00**

Table 5-17: Before and After PC Speeds Entire Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change	Significant?
Means	μ (b) - μ (a) > 0	-1.57mph	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	-0.70	Yes
% Obeying Advisory Speed	P (b) - P (a) < 0	3.94%	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	11.56%	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	11.75%	Yes

This indicated that most motorists were not complying with the advisory speed but after the DSM installation the proportion which utilized lower speeds was increased. The 85th percentile speed was reduced from 47 mph to 46 mph, and the coefficient of variation was approximately unchanged. From Table 5-17 it was seen that the mean and variance reduction as well as proportion increase was significant. Figure 5-26 and Figure 5-27 show that the After distribution of speeds shifts to the lower speed bins.

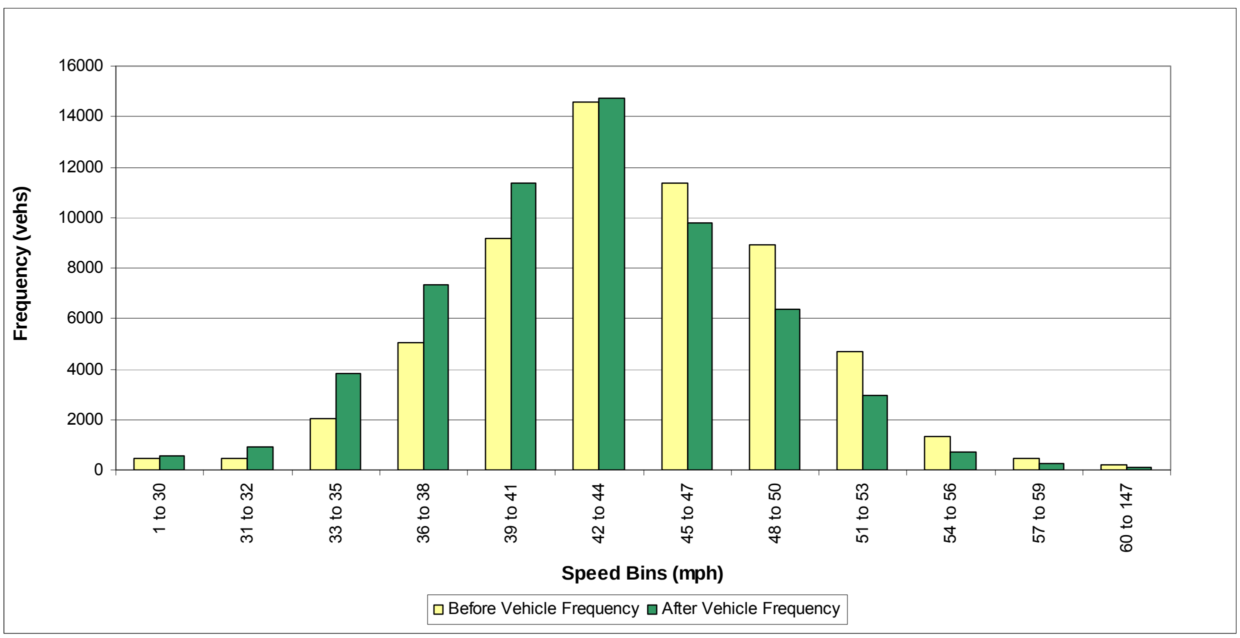


Figure 5-26: Before and After PC Speeds Entire Data Set Graph

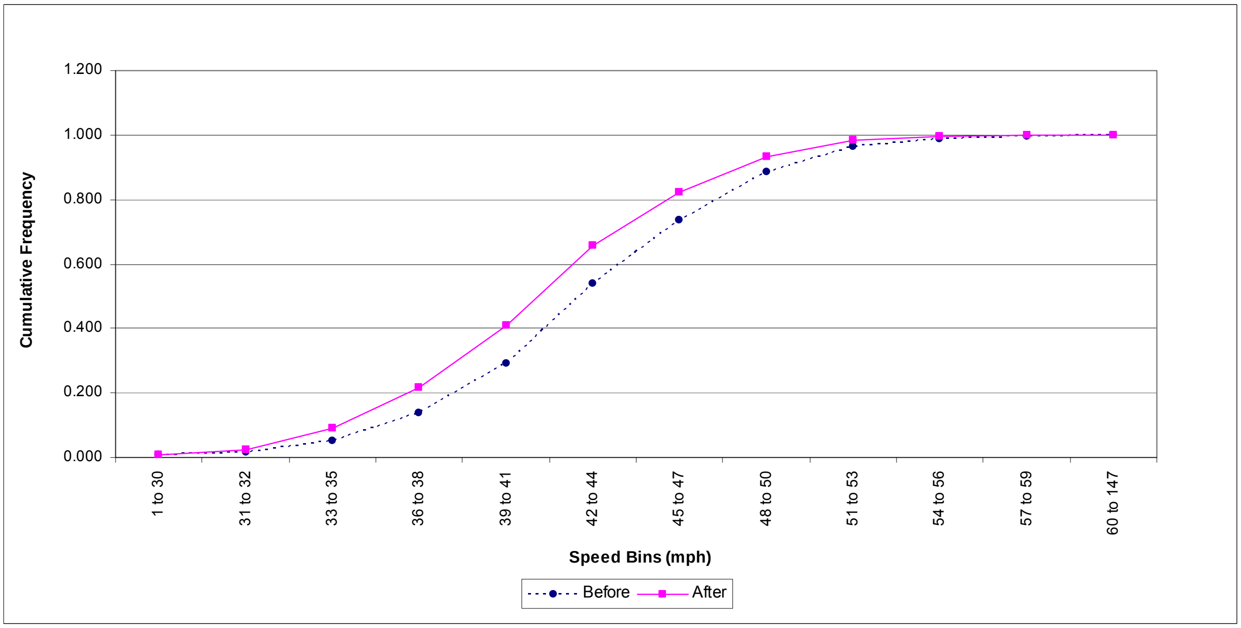


Figure 5-27: Before and After PC Speeds Entire Data Set Cumulative Distributions

5.2.2 Day and Time Night Data Set - Before and After PC Speeds

Table 5-18 presents the Before and After data and statistical parameters for the PC speeds Day and Night time data sets. Table 5-19 presents the summary of the hypothesis tests results. Figure 5-28 and Figure 5-31 provides frequency graphs of the Before and After speeds for the Day and Night time data sets respectively. Figure 5-29 and Figure 5-31 provides cumulative frequency graphs for the Day and Night time data respectively.

Table 5-18 shows that the mean decreased by 1.74 mph and 1.05 mph and the variance increased by 0.82 and decreased by 2.48 for the Day and Night data set respectively.

Table 5-18: Before and After PC Speeds Day and Night Time Data Set Summary

Speed (mph)	Before Vehicle Frequency				Total	After Vehicle Frequency				Total
	Percentage		Frequency			Percentage		Frequency		
	Day	Night	Day	Night		Day	Night	Day	Night	
1 to 30	0.007	0.011	280	169	**449**	0.009	0.009	390	157	**547**
31 to 32	0.005	0.015	231	242	**473**	0.014	0.019	590	329	**919**
33 to 35	0.024	0.065	1023	1032	**2055**	0.055	0.091	2299	1543	**3842**
36 to 38	0.068	0.133	2912	2119	**5031**	0.106	0.172	4446	2900	**7346**
39 to 41	0.136	0.209	5812	3340	**9152**	0.176	0.236	7382	3990	**11372**
42 to 44	0.244	0.259	10421	4130	**14551**	0.254	0.239	10665	4046	**14711**
45 to 47	0.209	0.152	8924	2424	**11348**	0.182	0.125	7656	2110	**9766**
48 to 50	0.173	0.095	7391	1522	**8913**	0.124	0.069	5212	1174	**6386**
51 to 53	0.093	0.044	3973	708	**4681**	0.059	0.028	2480	467	**2947**
54 to 56	0.028	0.011	1177	170	**1347**	0.014	0.008	592	128	**720**
57 to 59	0.010	0.004	414	68	**482**	0.005	0.002	199	37	**236**
60 to 147	0.005	0.003	163	34	**197**	0.001	0.001	67	22	**89**
Total Vehicles			**42721**	**15958**	**58679**	---	---	**41978**	**16903**	**58881**
Average Speed (mph)			**44.85**	**42.29**	**---**	**---**	**---**	**43.11**	**41.24**	**---**
Variance			**28.60**	**28.71**	**---**	**---**	**---**	**29.42**	**26.23**	**---**
Coefficient of Variance			**0.12**	**0.13**	---	---	---	**0.13**	**0.12**	---
% Obeying Advisory Speed			**3.59**	**9.04**	---	---	---	**7.81**	**12.00**	---
% Obeying Advisory Speed + 5Mph			**24.01**	**43.25**	---	---	---	**35.99**	**52.77**	---
% Obeying Advisory Speed + 10 Mph			**48.40**	**69.13**	---	---	---	**61.39**	**76.70**	---
85th Percentile (mph)			**47.00**	**46.00**	**---**	**---**	**---**	**46.00**	**44.00**	**---**

Table 5-19: Before and After PC Speeds Entire Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change		Significant?	
		Day Time	Night Time	Day Time	Night Time
Means	μ (b) - μ (a) > 0	-1.74mph	- 1.05mph	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	0.82	-2.48	No	Yes
% Obeying Advisory Speed	P (b) - P (a) < 0	4.22%	2.96%	Yes	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	11.98%	9.52%	Yes	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	12.99%	7.57%	Yes	Yes

Table 5-19 shows that that mean and variance reduction (except during the day time) as well as proportion increase was significant. This indicated that the DSM system was more effective at night in reducing variance of PC speeds. This is contrary to what was seen with the Approach data in which variance reduction was less at night. This indicates that during the night, even though the initial approach variance was high, the DSM system encouraged variance reduction as vehicles entered the curve. This could be due to the fact that the sign was very visible at night as it was the only illuminating source at the rural unlit interchange. Advisory speed compliance increased by only 4.22% and 2.96%, however compliance with the advisory speed + 5 mph as well as advisory speed + 10 mph increased by 11.98% and 9.52% as well as 12.99% and 7.59% during the Day and Night respectively. This indicates that although variance is reduced at night, the increase in proportion of vehicles in the lower speed ranges is better during the day. The 85th percentile speed was reduced from 47 mph to 46 mph and 46 mph to 44 mph for the Day and Night data sets respectively. The coefficient of variation was approximately unchanged for both data sets. Figure 5-28 to Figure 5-31 show clearly that the After distribution of speeds shifts to the lower speed bins as compared to the Before speeds and that the shift is more pronounced during the day.

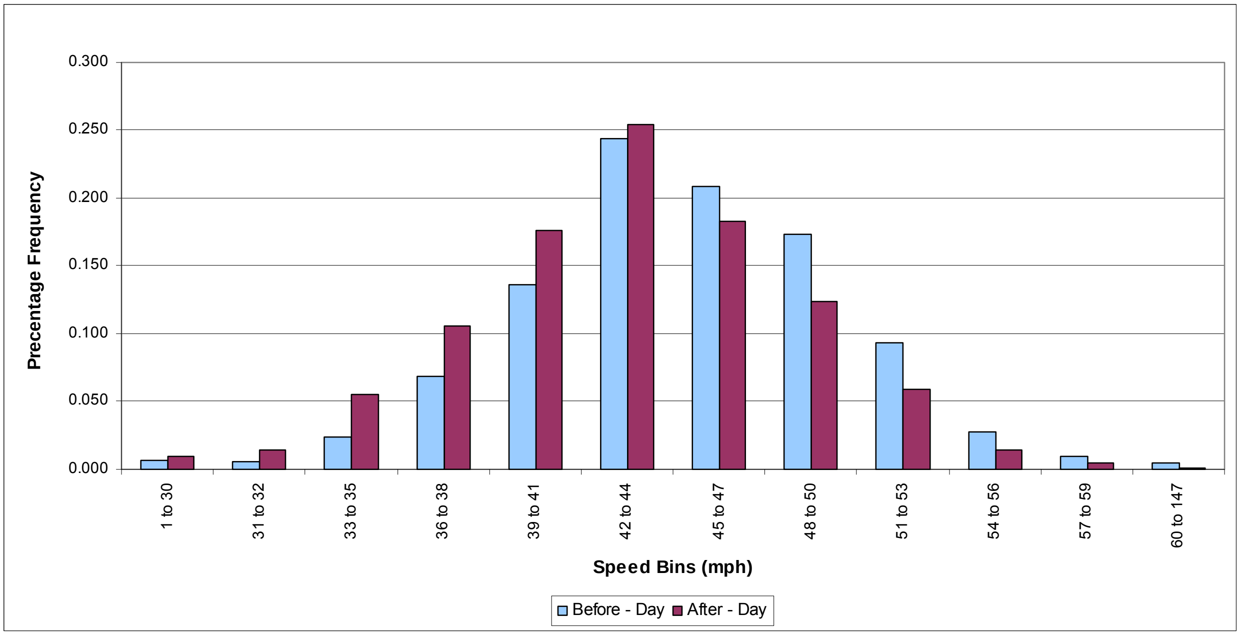


Figure 5-28: Before and After PC Speeds Day Time Frequency Graph

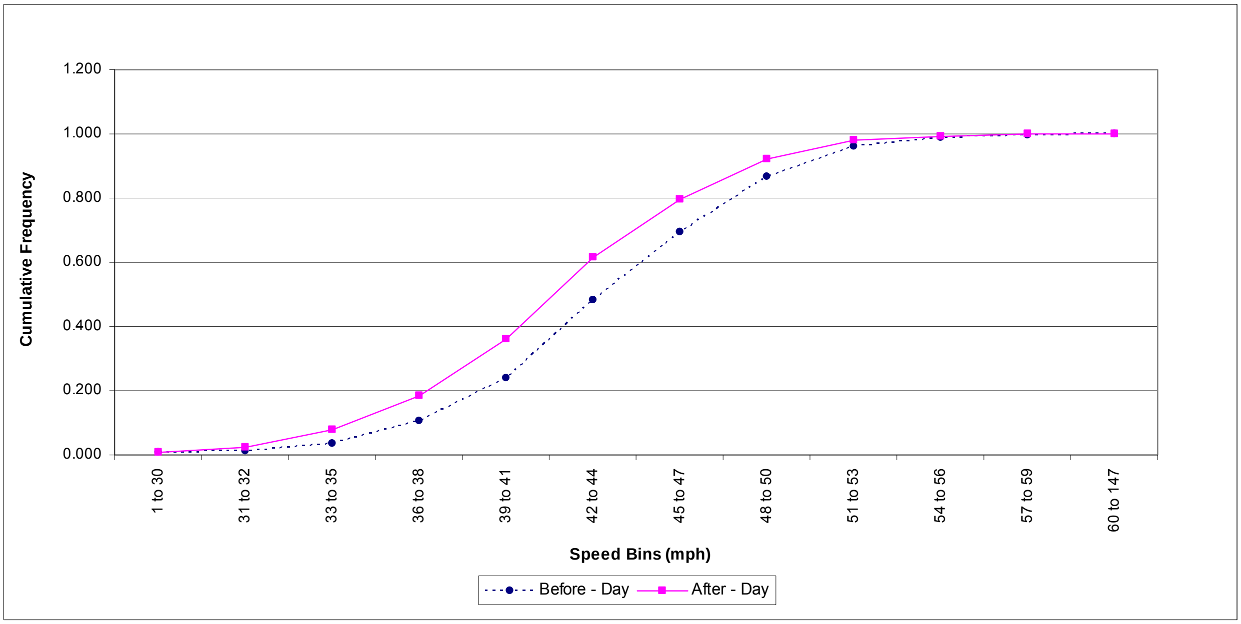


Figure 5-29: Before and After PC Day Time Speeds Cumulative Distributions

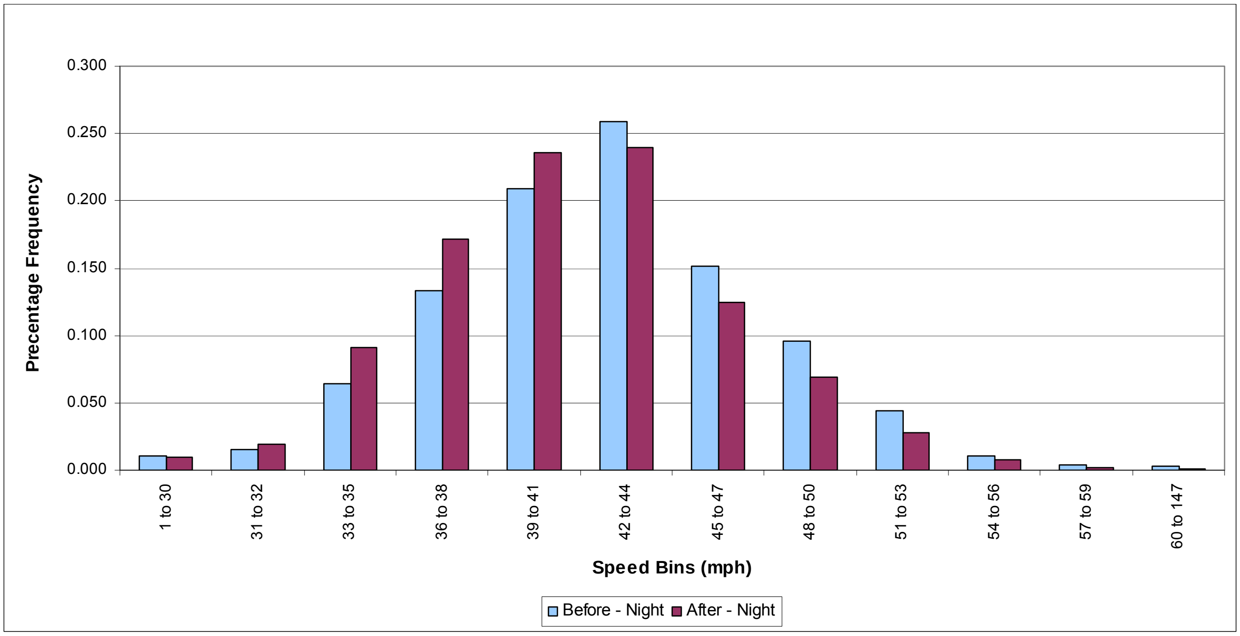


Figure 5-30: Before and After PC Speeds Night Time Frequency Graph

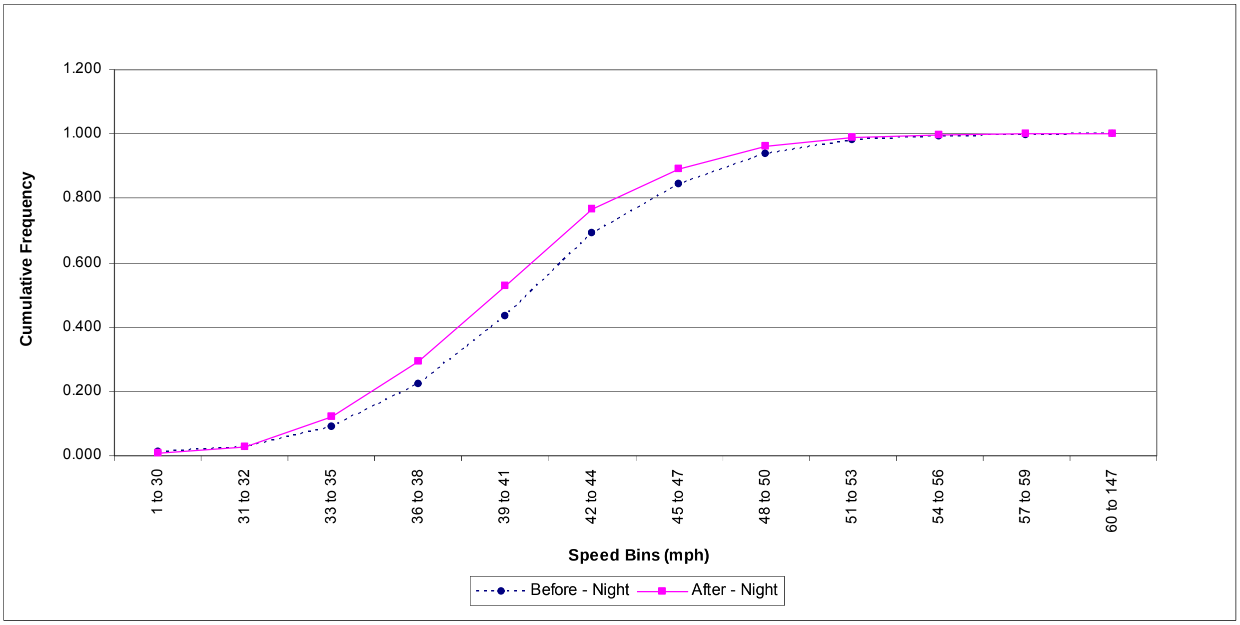


Figure 5-31: Before and After PC Night Time Speeds Cumulative Distributions

5.2.3 Daily Data Set - Before and After PC Speeds

Table 5-20 presents the Before and After data and statistical parameters for the PC speeds Daily data sets. Table 5-21 presents the summary of the hypothesis tests results. Figure 5-32 to Figure 5-38 provides frequency graphs of the Before and After speeds for the data sets.

The mean decreased from 44.90 mph to 42.96 mph (difference of 1.94 mph) on weekdays (Monday to Thursday) and from 43.63 mph to 42.73 mph (difference of 0.90 mph) on weekends (Saturday and Sunday). The variance decreased from 28.34 to 27.77 (difference of 0.57) on the weekdays and increased from 25.87 to 27.56 (increase of 1.69) on weekends. This indicated that the DSM system was better at reducing mean and variance on weekdays than on weekends. On weekdays and weekends, advisory speed compliance increased by only 3.80% and 2.64%, however compliance with the advisory speed + 5 mph as well as advisory speed + 10 mph increased by 13.42% and 8.59% as well as 15.26% and 7.36% respectively. This indicated that the DSM system was more effective on weekdays at influencing drivers to drive closer to the advisory speed when entering the study curve. The 85th percentile speed did not vary from weekday to weekend and the reduction was generally 48 mph to 46 mph. The coefficient of variation was generally unchanged for the daily data sets. From Table 5-6 it was seen that mean and variance (except on Mondays and Sundays) reduction as well as proportion increase was significant. Figure 5-7 to Figure 5-12 show clearly that the After distribution of speeds shifts to the lower speed bins as compared to the Before speeds. The shift was not as defined on the weekend as on the weekdays and this could be attributed to lower volumes and motorists' perception that speed limit enforcement is not as likely on the weekend.

Table 5-20: Before and After PC Speeds Daily Data Set Summary

Speed (mph)	Before Daily Vehicle Frequency								After Daily Vehicle Frequency							
	05/22/07 & 6/12/2007 Tue	05/23/07 & 6/13/2007 Wed	05/24/07 & 6/07/2007 Thu	05/25/07 & 6/08/2007 Fri	05/26/07 & 6/09/2007 Sat	05/20/07 & 6/10/2007 Sun	05/21/07 & 6/11/2007 Mon	Total	07/03/07 & 7/10/2007 Tue	07/18/07 & 7/11/2007 Wed	07/05/07 & 7/12/2007 Thu	07/06/07 & 7/13/2007 Fri	07/07/07 & 7/14/2007 Sat	07/01/07 & 7/08/2007 Sun	07/02/07 & 7/09/2007 Mon	Total
1 to 30	56	34	44	182	75	25	33	**449**	91	35	81	188	46	49	57	**547**
31 to 32	45	38	51	154	76	50	59	**473**	87	66	134	308	107	103	114	**919**
33 to 35	220	197	204	632	337	218	247	**2055**	500	303	547	1106	459	418	509	**3842**
36 to 38	630	509	507	1323	779	587	696	**5031**	971	739	1192	1625	965	847	1007	**7346**
39 to 41	1131	1025	1091	1921	1449	1211	1324	**9152**	1648	1325	1766	1942	1667	1470	1554	**11372**
42 to 44	1964	1977	1959	2285	2095	2012	2259	**14551**	2180	2221	2276	1977	2053	1891	2113	**14711**
45 to 47	1748	1744	1845	1312	1509	1502	1688	**11348**	1483	1644	1413	1293	1245	1274	1414	**9766**
48 to 50	1551	1629	1565	933	955	1080	1200	**8913**	900	1205	920	797	800	835	929	**6386**
51 to 53	900	886	866	553	423	479	574	**4681**	433	570	392	350	360	400	442	**2947**
54 to 56	255	294	253	167	112	119	147	**1347**	107	139	104	74	88	98	110	**720**
57 to 59	86	112	88	70	34	50	42	**482**	29	46	35	28	35	29	34	**236**
60 to 147	54	40	37	27	8	12	19	**197**	11	13	15	8	15	17	10	**89**
Total	**8640**	**8485**	**8510**	**9559**	**7852**	**7345**	**8288**	**58679**	**8440**	**8306**	**8875**	**9696**	**7840**	**7431**	**8293**	**58881**
Ave Speed (mph)	**45.02**	**45.37**	**45.16**	**42.34**	**43.23**	**44.03**	**44.04**	**---**	**42.74**	**43.89**	**42.44**	**41.02**	**42.58**	**42.88**	**42.78**	**---**
Variance	**30.66**	**28.77**	**28.50**	**34.92**	**27.00**	**24.74**	**25.44**	---	**28.26**	**26.16**	**28.35**	**32.87**	**26.94**	**28.18**	**28.30**	---
Coefficient of Variance	**0.12**	**0.12**	**0.12**	**0.14**	**0.12**	**0.11**	**0.11**	---	**0.12**	**0.12**	**0.13**	**0.14**	**0.12**	**0.12**	**0.12**	---
% Obeying Advisory Speed	**3.72**	**3.17**	**3.51**	**10.13**	**6.21**	**3.99**	**4.09**	---	**8.03**	**4.86**	**8.59**	**16.52**	**7.81**	**7.67**	**8.20**	---
% Obeying Advisory Speed + 5Mph	**24.10**	**21.25**	**22.29**	**44.06**	**34.59**	**28.47**	**28.46**	---	**39.06**	**29.71**	**41.92**	**53.31**	**41.38**	**38.85**	**39.08**	---
% Obeying Advisory Speed + 10 Mph	**46.83**	**44.55**	**45.31**	**67.97**	**61.27**	**55.86**	**55.72**	---	**64.89**	**56.45**	**67.56**	**73.70**	**67.56**	**64.30**	**64.56**	---
85th Percentile (mph)	**50.00**	**49.00**	**47.00**	**46.00**	**46.00**	**47.00**	**47.00**	**---**	**46.00**	**47.00**	**46.00**	**44.00**	**46.00**	**46.00**	**46.00**	**---**

Table 5-21: Before and After PC Speeds Daily Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Parameter Change		Significant?						
		Weekday	Weekend	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Means	μ (b) - μ (a) > 0	-1.93	-0.90	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	-0.57	1.69	No	Yes	Yes	Yes	Yes	Yes	No
% Obeying Advisory Speed	P (b) - P (a) < 0	-3.80%	-2.64%	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	-13.42%	-8.59%	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	-15.26%	-7.36%	Yes	Yes	Yes	Yes	Yes	Yes	Yes

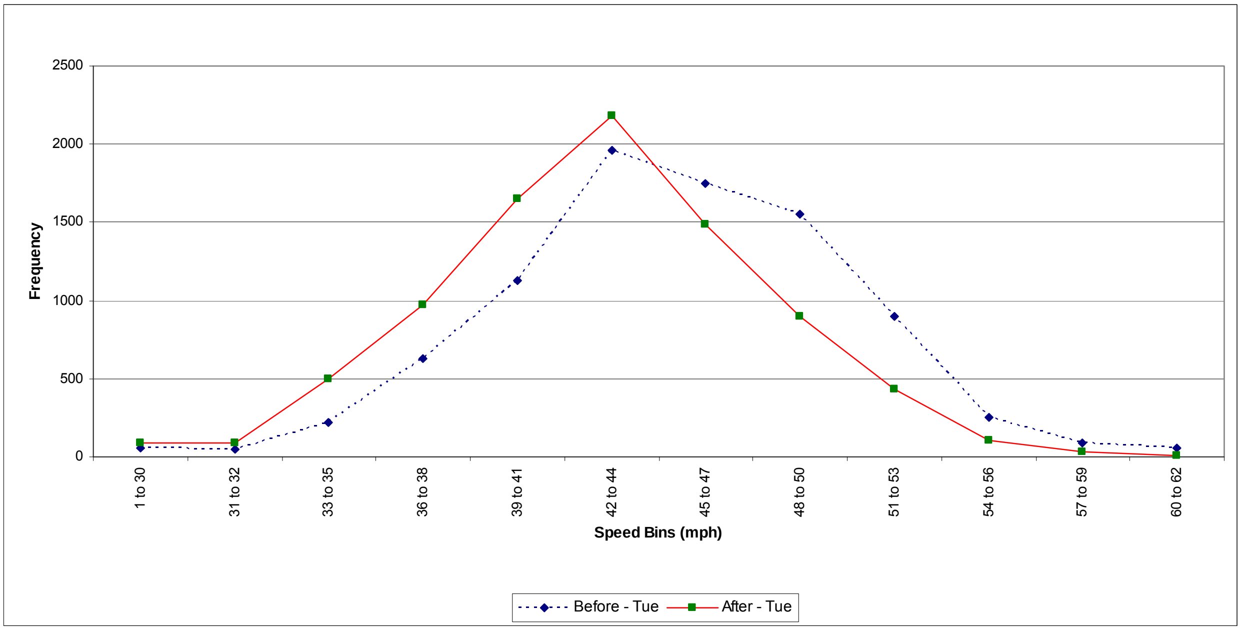


Figure 5-32: Before and After PC Speeds Tuesday Frequency Graph

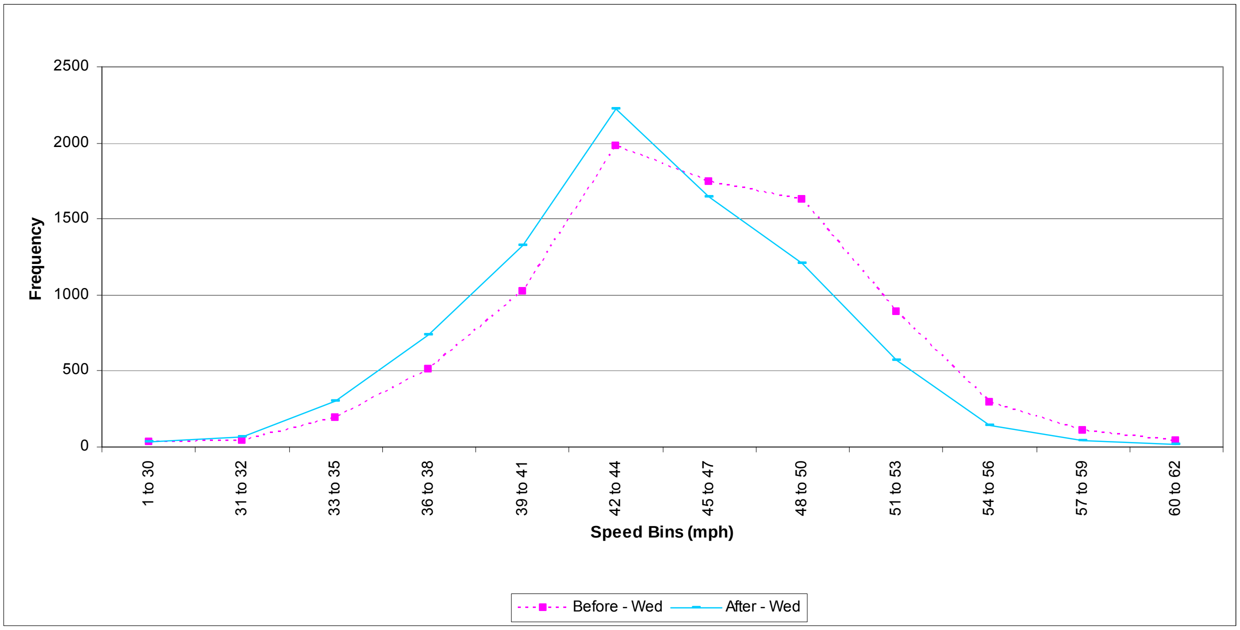


Figure 5-33: Before and After PC Speeds Wednesday Frequency Graph

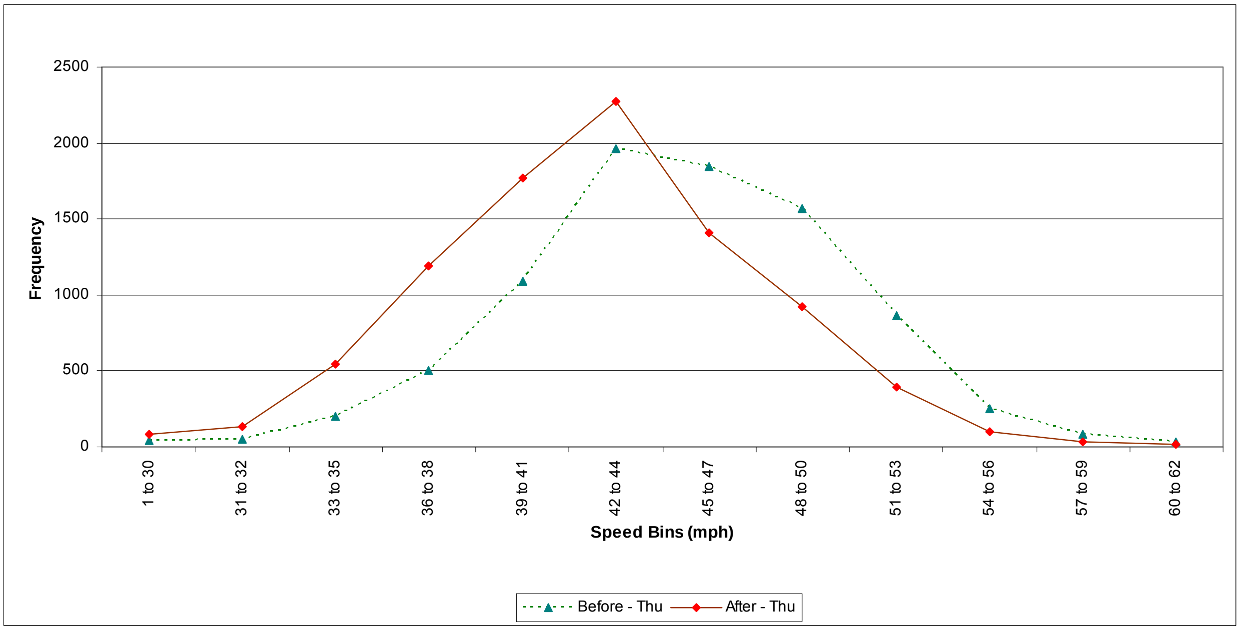


Figure 5-34: Before and After PC Speeds Thursday Frequency Graph

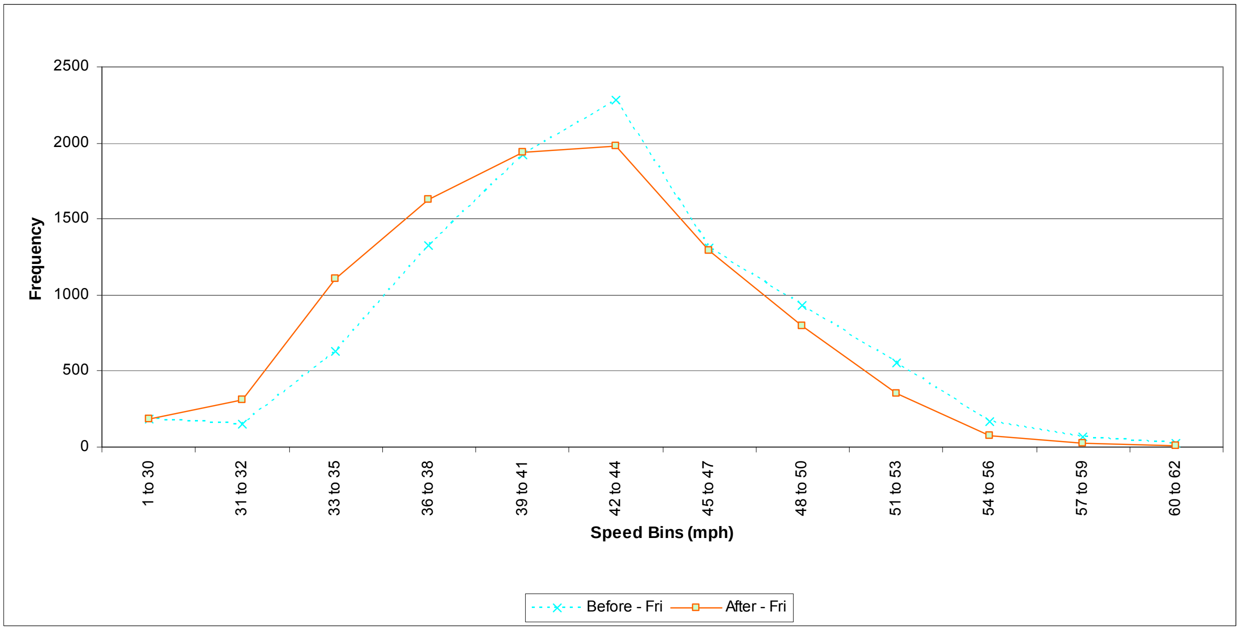


Figure 5-35: Before and After PC Speeds Friday Frequency Graph

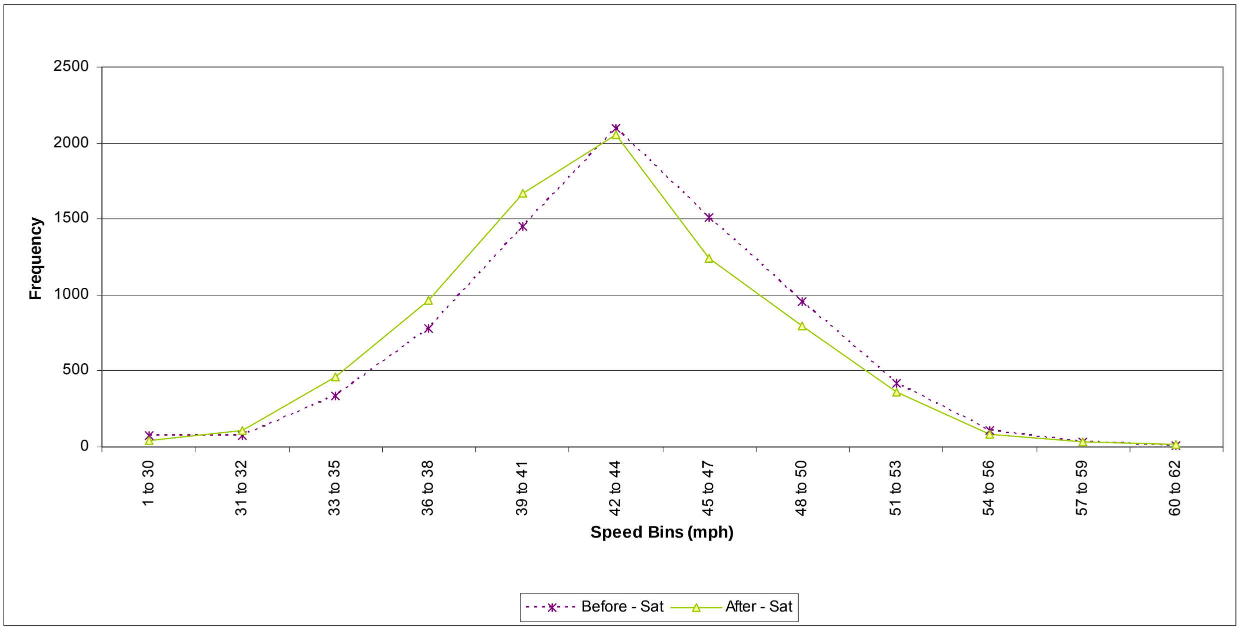


Figure 5-36: Before and After PC Speeds Saturday Frequency Graph

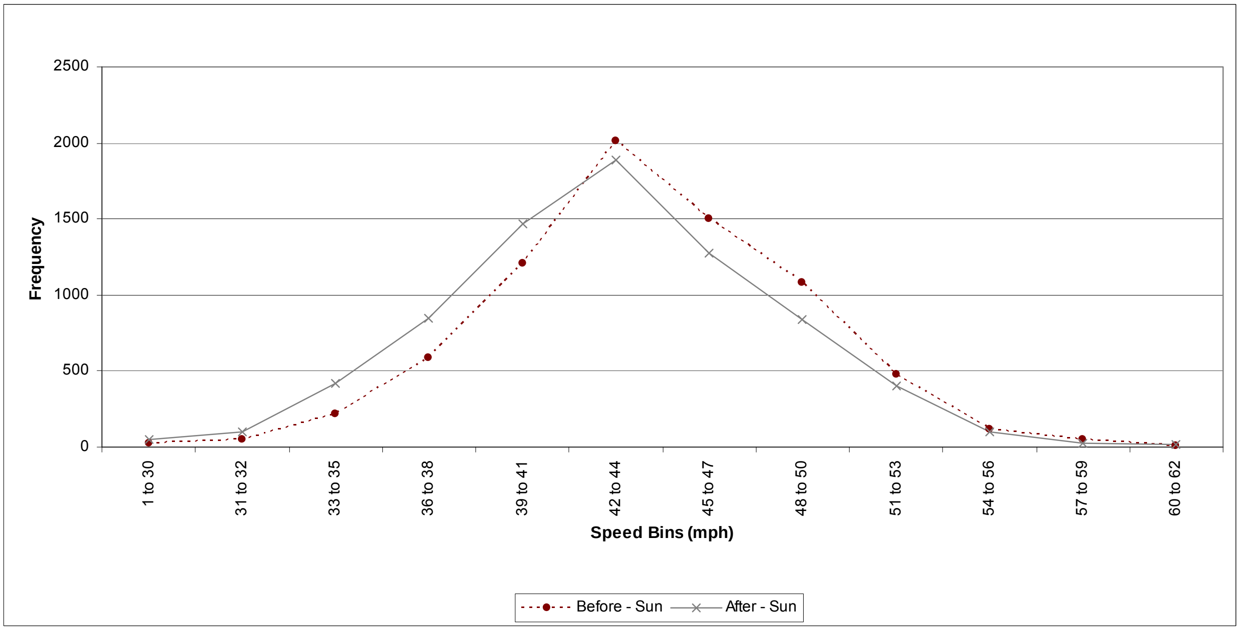


Figure 5-37: Before and After PC Speeds Sunday Frequency Graph

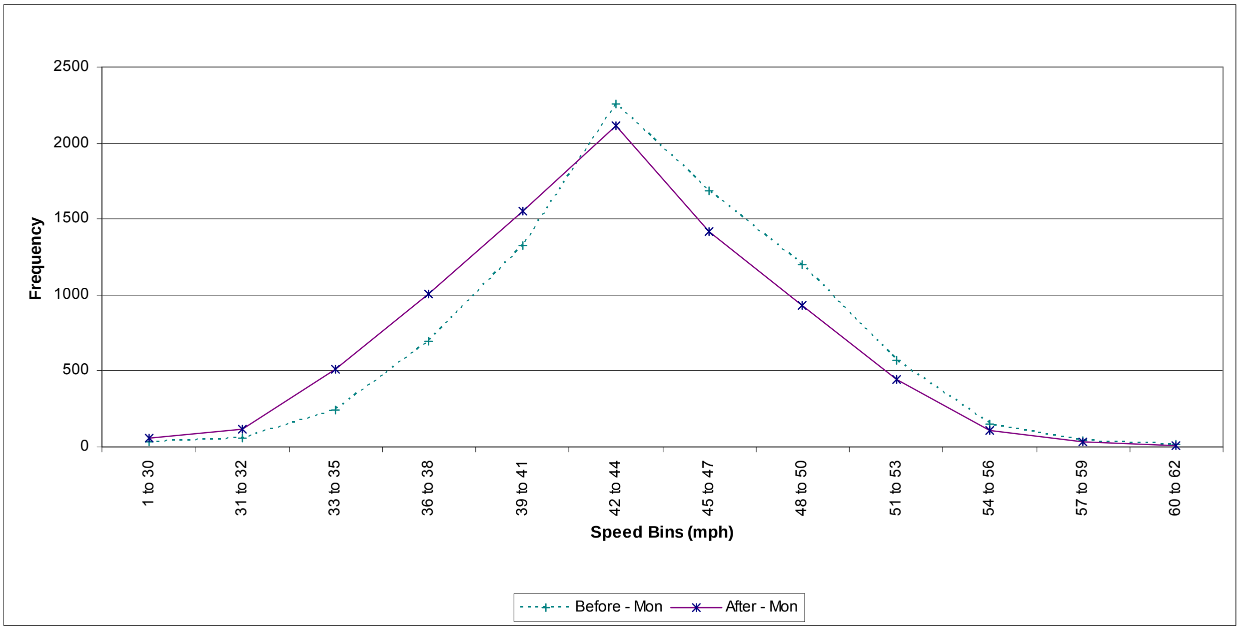


Figure 5-38: Before and After PC Speeds Monday Frequency Graph

5.2.4 Time of Day Data Set - Before and After PC Speeds

Table 5-22 presents the Before and After data and statistical parameters for the PC speeds Time of Day data sets. Table 5-23 presents the summary of the hypothesis tests results. Figure 5-39 to Figure 5-45 provides frequency graphs of the Before and After speeds for the data sets.

From Table 5-22 it can be seen that the speed mean was significantly reduced. Variance reduction was significant except during the 1 PM to 4 PM and 4 PM to 6 PM time periods. Examination of Table 5-22 showed a larger number of vehicles in the lower speed bins as compared to the other time periods.

Table 5-22: Before and After PC Speeds TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency							Total	After TOD Vehicle Frequency							Total
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	
1 to 30	49	6	14	13	33	144	190	**449**	30	10	11	17	53	182	244	**547**
31 to 32	48	11	18	23	38	54	281	**473**	77	15	25	16	74	242	470	**919**
33 to 35	208	61	93	97	162	295	1139	**2055**	312	59	93	132	342	869	2035	**3842**
36 to 38	481	156	210	281	480	812	2611	**5031**	696	194	281	325	804	1355	3691	**7346**
39 to 41	785	353	458	581	1098	1625	4252	**9152**	1120	407	601	804	1569	1875	4996	**11372**
42 to 44	1098	662	955	1139	2388	2561	5748	**14551**	1433	662	1073	1321	2446	2373	5403	**14711**
45 to 47	763	661	889	1116	2167	2021	3731	**11348**	854	648	879	1079	1943	1478	2885	**9766**
48 to 50	645	609	766	914	1959	1516	2504	**8913**	559	496	596	790	1441	935	1569	**6386**
51 to 53	343	371	425	553	1088	783	1118	**4681**	269	264	288	381	728	426	591	**2947**
54 to 56	85	140	127	170	309	208	308	**1347**	91	61	70	86	187	100	125	**720**
57 to 59	47	62	40	62	103	66	102	**482**	28	31	27	31	50	34	35	**236**
60 to 147	23	29	20	32	42	11	40	**197**	13	14	7	12	16	9	18	**89**
Total	**4575**	**3121**	**4015**	**4981**	**9867**	**10096**	**22024**	**58679**	**5482**	**2861**	**3951**	**4994**	**9653**	**9878**	**22062**	**58881**
Ave Speed (mph)	**43.64**	**46.02**	**45.42**	**45.54**	**45.59**	**44.02**	**42.87**	---	**42.70**	**44.93**	**44.36**	**44.43**	**44.03**	**41.80**	**41.21**	---
Variance	**33.42**	**30.14**	**27.19**	**27.95**	**25.86**	**29.43**	**28.28**	—	**28.24**	**27.01**	**23.96**	**24.23**	**27.08**	**32.44**	**26.19**	—
Coefficient of Variance	**0.13**	**0.12**	**0.11**	**0.12**	**0.11**	**0.12**	**0.12**	—	**0.12**	**0.12**	**0.11**	**0.11**	**0.12**	**0.14**	**0.12**	—
% Obeying Advisory Speed	**6.67**	**2.50**	**3.11**	**2.67**	**2.36**	**4.88**	**7.31**	—	**7.64**	**2.94**	**3.26**	**3.30**	**4.86**	**13.09**	**12.46**	—
% Obeying Advisory Speed + 5Mph	**34.34**	**18.81**	**19.75**	**19.98**	**18.35**	**29.02**	**38.47**	—	**40.77**	**23.94**	**25.59**	**25.91**	**29.44**	**45.79**	**51.84**	—
% Obeying Advisory Speed + 10 Mph	**58.34**	**40.02**	**43.54**	**42.84**	**42.56**	**54.39**	**64.57**	—	**66.91**	**47.08**	**52.75**	**52.36**	**54.78**	**69.81**	**76.33**	—
85th Percentile (mph)	**47.00**	**49.00**	**49.00**	**49.00**	**49.00**	**47.00**	**46.00**	---	**46.00**	**47.00**	**47.00**	**47.00**	**47.00**	**46.00**	**44.00**	---

Table 5-23: Before and After PC Speeds TOD Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	Yes	Yes	Yes	No	No	Yes
% Obeying Advisory Speed	P (b) - P (a) < 0	Yes	No	No	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Advisory speed compliance and reduction in the proportion of vehicles in the higher speed ranges was generally seen to be significant except during the 7 AM to 9 AM and 9 AM to 11 AM time periods. The 85th percentile speed was generally reduced from 49 mph to 47 mph, and the coefficient of variation was approximately unchanged. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds. This is consistent with the trend seen thus far.

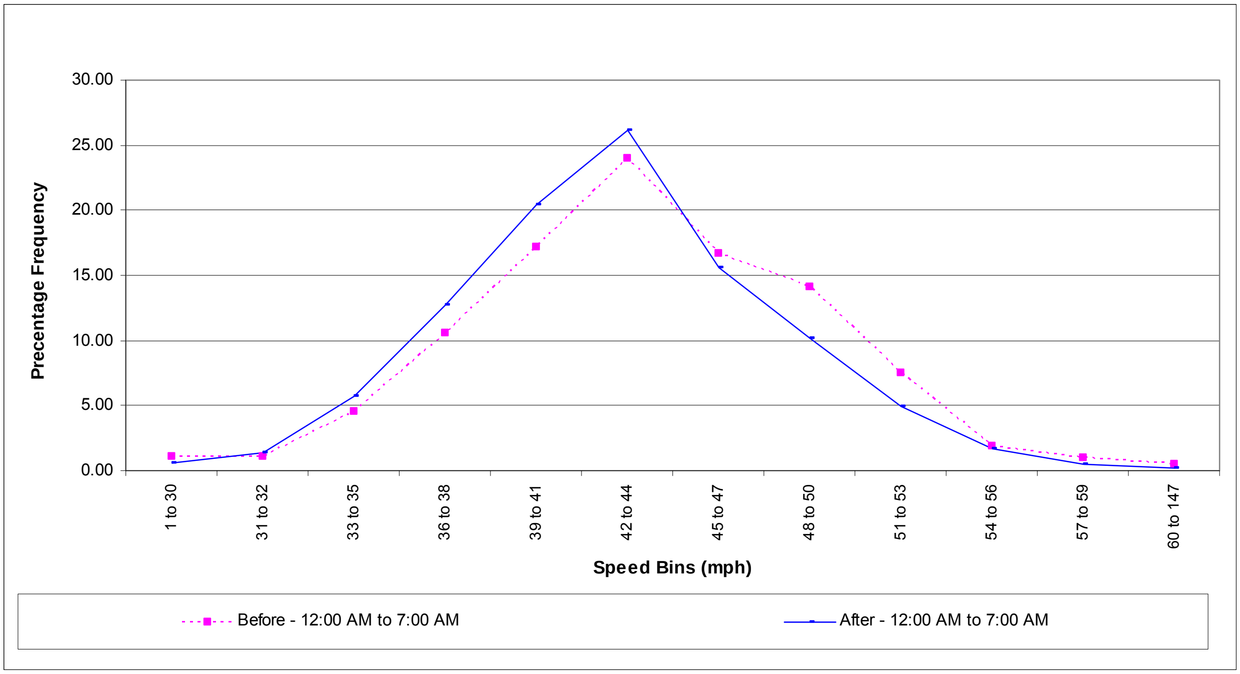


Figure 5-39: Before and After PC Speeds TOD 12AM-7AM Percentage Frequency Graph

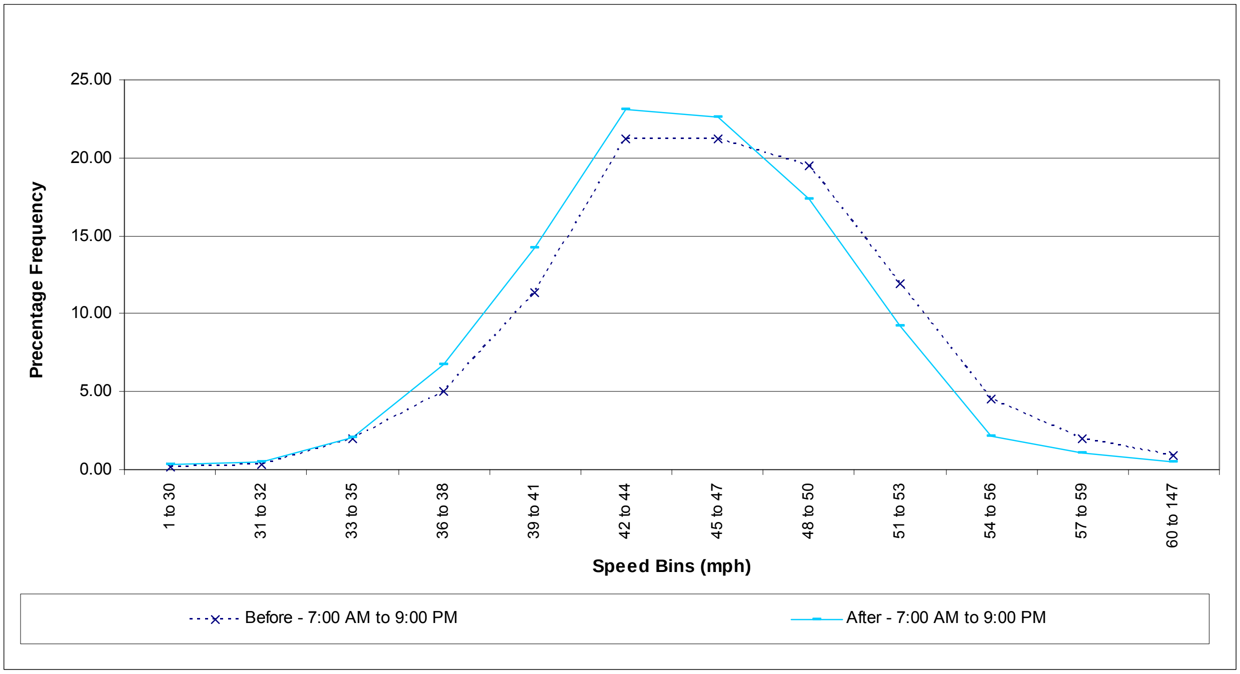


Figure 5-40: Before and After PC Speeds TOD 7AM-9AM Percentage Frequency Graph

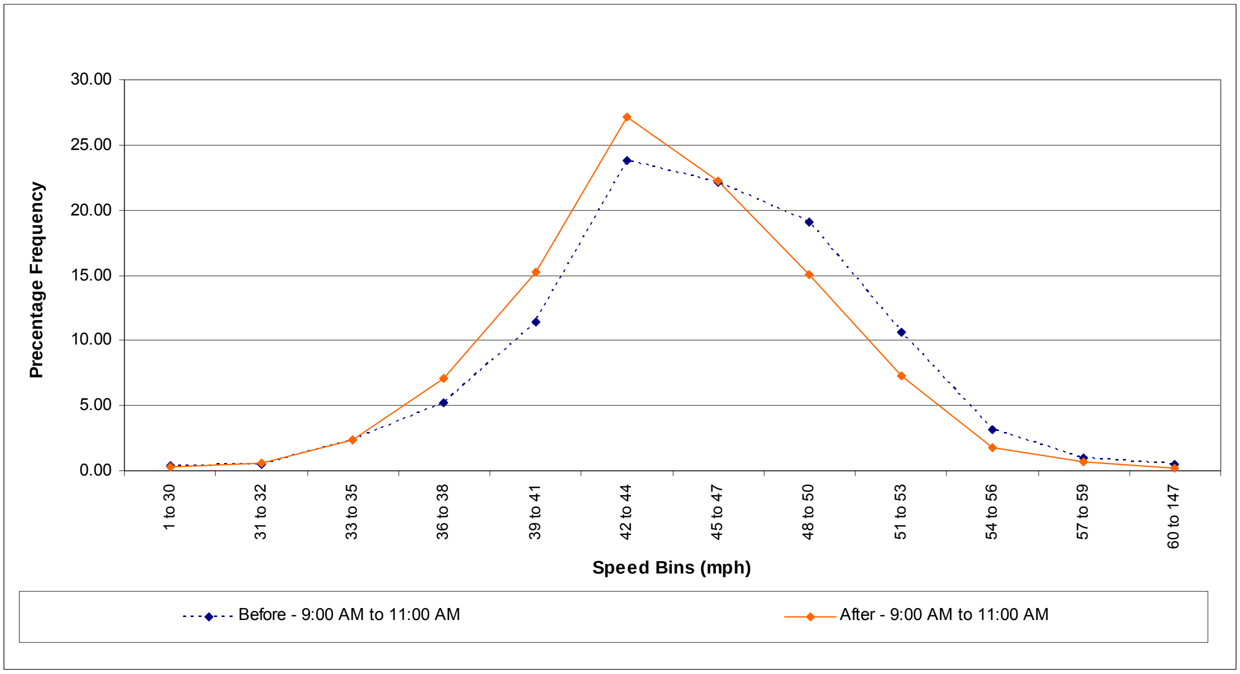


Figure 5-41: Before and After PC Speeds TOD 9AM-11AM Percentage Frequency Graph

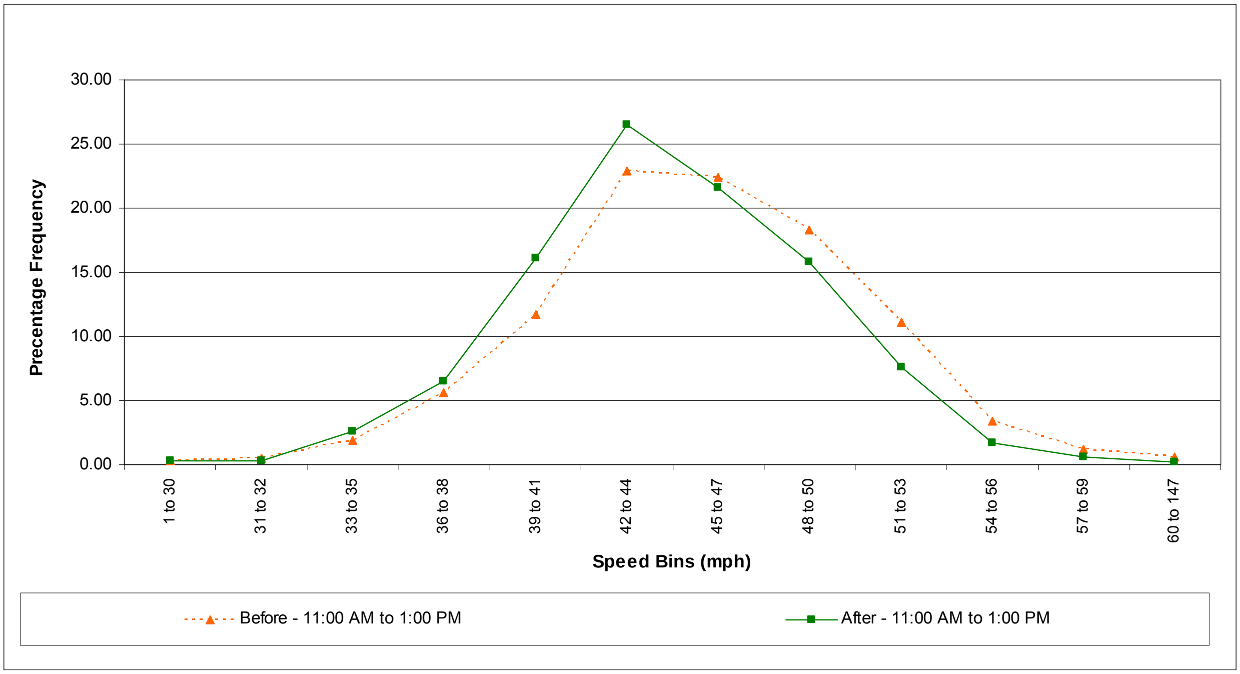


Figure 5-42: Before and After PC Speeds TOD 11AM-1PM Percentage Frequency Graph

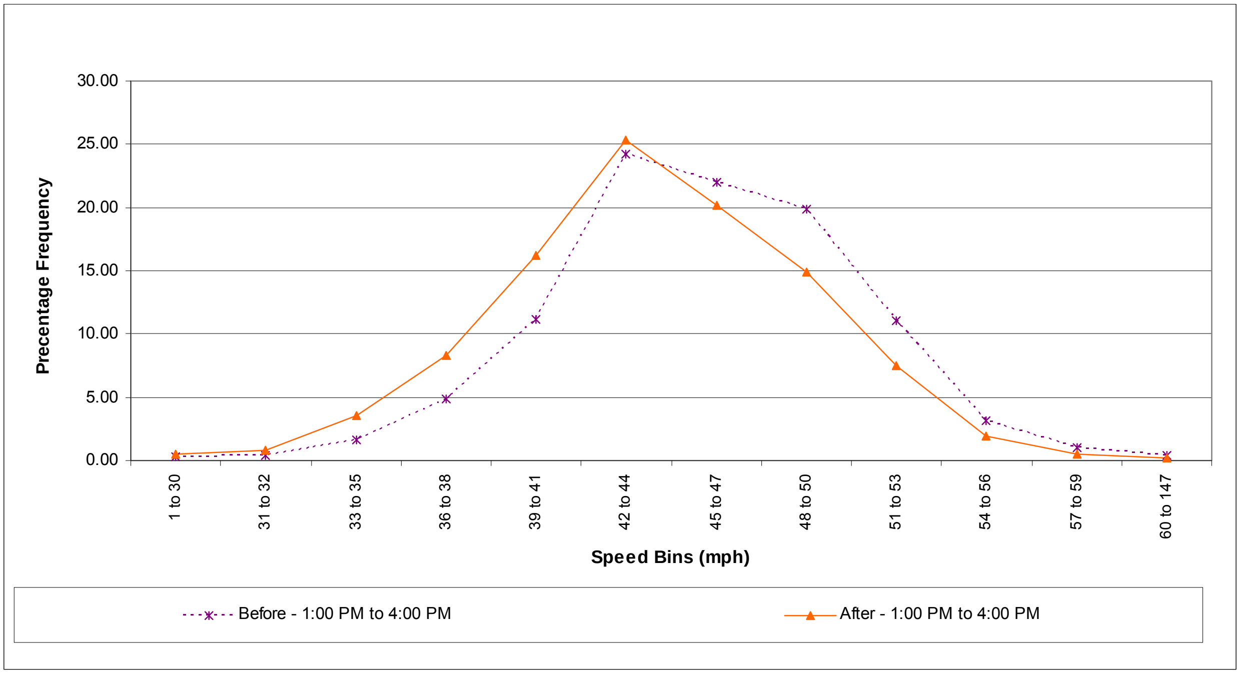


Figure 5-43: Before and After PC Speeds TOD 1PM-4PM Percentage Frequency Graph

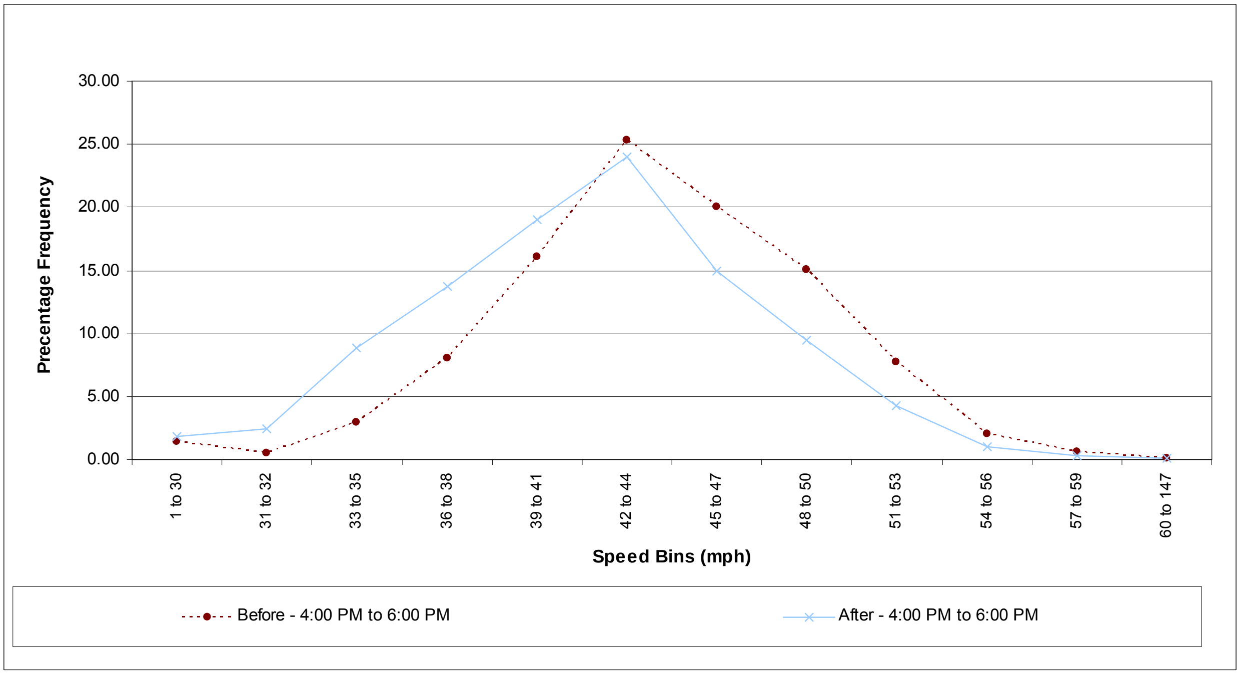


Figure 5-44: Before and After PC Speeds TOD 4PM-6PM Percentage Frequency Graph

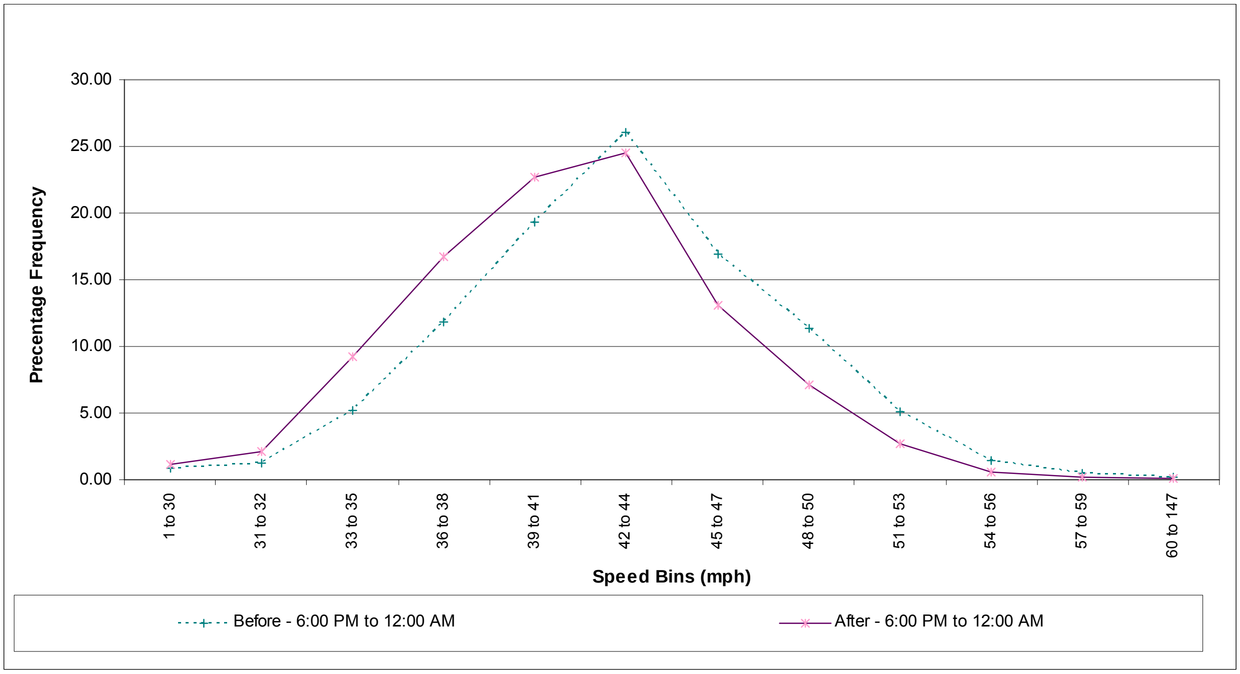


Figure 5-45: Before and After PC Speeds TOD 6PM-12AM Percentage Frequency Graph

5.2.5 Weekday TOD Data Set - Before and After PC Speeds

Table 5-24 presents the Before and After data and statistical parameters for the PC speeds Weekday Time of Day data sets. Table 5-25 presents the summary of the hypothesis tests results. Figure 5-46 to Figure 5-52 provides frequency graphs of the Before and After speeds for the data sets.

From Table 5-25 it can be seen that generally both the speed mean and variance reduction was significant. During the 4 PM to 6 PM time period the variance was not significantly reduced.

Table 5-24: Before and After PC Speeds Weekday TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency								After TOD Vehicle Frequency							
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total
1 to 30	20	5	11	7	18	12	94	**167**	13	7	8	13	27	60	136	**264**
31 to 32	12	5	13	12	12	19	120	**193**	35	5	17	9	24	68	243	**401**
33 to 35	82	41	68	41	61	114	461	**868**	163	38	47	79	161	309	1062	**1859**
36 to 38	248	105	137	154	249	288	1161	**2342**	392	116	161	176	405	599	2060	**3909**
39 to 41	435	214	289	313	548	705	2067	**4571**	644	265	284	453	883	1031	2733	**6293**
42 to 44	645	412	545	625	1255	1360	3317	**8159**	841	430	607	735	1436	1562	3179	**8790**
45 to 47	472	440	530	643	1243	1337	2360	**7025**	530	393	507	620	1227	1039	1638	**5954**
48 to 50	430	393	479	569	1196	1093	1785	**5945**	340	319	381	449	875	656	934	**3954**
51 to 53	234	226	236	355	732	596	847	**3226**	178	166	166	234	464	297	332	**1837**
54 to 56	53	94	80	103	214	165	240	**949**	60	41	48	52	116	74	69	**460**
57 to 59	26	39	21	38	73	52	79	**328**	14	19	19	23	34	21	14	**144**
60 to 147	16	21	15	22	32	10	34	**150**	5	8	2	10	10	4	10	**49**
Total	**2673**	**1995**	**2424**	**2882**	**5633**	**5751**	**12565**	**33923**	**3215**	**1807**	**2247**	**2853**	**5662**	**5720**	**12410**	**33914**
Ave Speed (mph)	**44.29**	**46.05**	**45.28**	**45.89**	**46.14**	**45.37**	**43.78**	—	**42.96**	**44.95**	**44.61**	**44.54**	**44.40**	**42.94**	**41.34**	—
Variance	**30.93**	**30.66**	**28.87**	**27.79**	**25.96**	**24.33**	**28.54**	—	**27.21**	**26.60**	**24.47**	**25.75**	**25.69**	**27.72**	**25.77**	—
Coefficient of Variance	**0.13**	**0.12**	**0.12**	**0.11**	**0.11**	**0.11**	**0.12**	—	**0.12**	**0.11**	**0.11**	**0.11**	**0.11**	**0.12**	**0.12**	—
% Obeying Advisory Speed	**4.26**	**2.56**	**3.80**	**2.08**	**1.62**	**2.52**	**5.37**	—	**6.56**	**2.77**	**3.20**	**3.54**	**3.74**	**7.64**	**11.61**	—
% Obeying Advisory Speed + 5Mph	**29.82**	**18.55**	**21.37**	**18.29**	**15.76**	**19.79**	**31.06**	—	**38.79**	**23.85**	**23.01**	**25.59**	**26.49**	**36.14**	**50.23**	—
% Obeying Advisory Speed + 10 Mph	**53.95**	**39.20**	**43.85**	**39.97**	**38.04**	**43.44**	**57.46**	—	**64.95**	**47.65**	**50.02**	**51.35**	**51.85**	**63.44**	**75.85**	—
85th Percentile (mph)	**47.00**	**49.00**	**47.00**	**49.00**	**49.00**	**47.00**	**47.00**	—	**46.00**	**47.00**	**47.00**	**47.00**	**47.00**	**46.00**	**44.00**	—

Table 5-25: Before and After PC Speeds Wkday TOD Data Set Hypothesis Tests Summary

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	Yes	Yes	Yes	Yes	No	Yes
% Obeying Advisory Speed	P (b) - P (a) < 0	Yes	No	No	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	Yes	Yes	No	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Advisory speed compliance and reduction in the proportion of vehicles in the higher speed ranges was generally seen to be significant except during the 7 AM to 9 AM and 9 AM to 11 AM time periods. The 85th percentile speed was generally only slightly reduced from 48 mph to 47 mph, and the coefficient of variation was approximately unchanged. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds. This is consistent with the trends seen thus far.

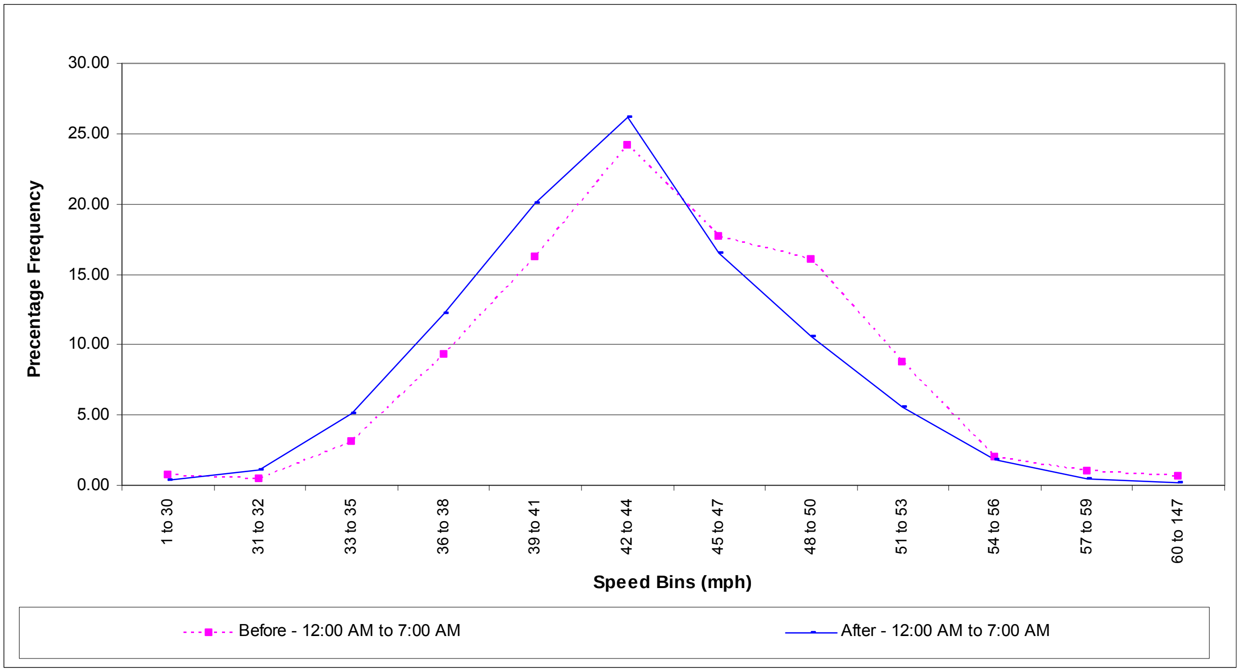


Figure 5-46: Before and After PC Speeds Wkday TOD 12AM-7AM Percentage Frequency

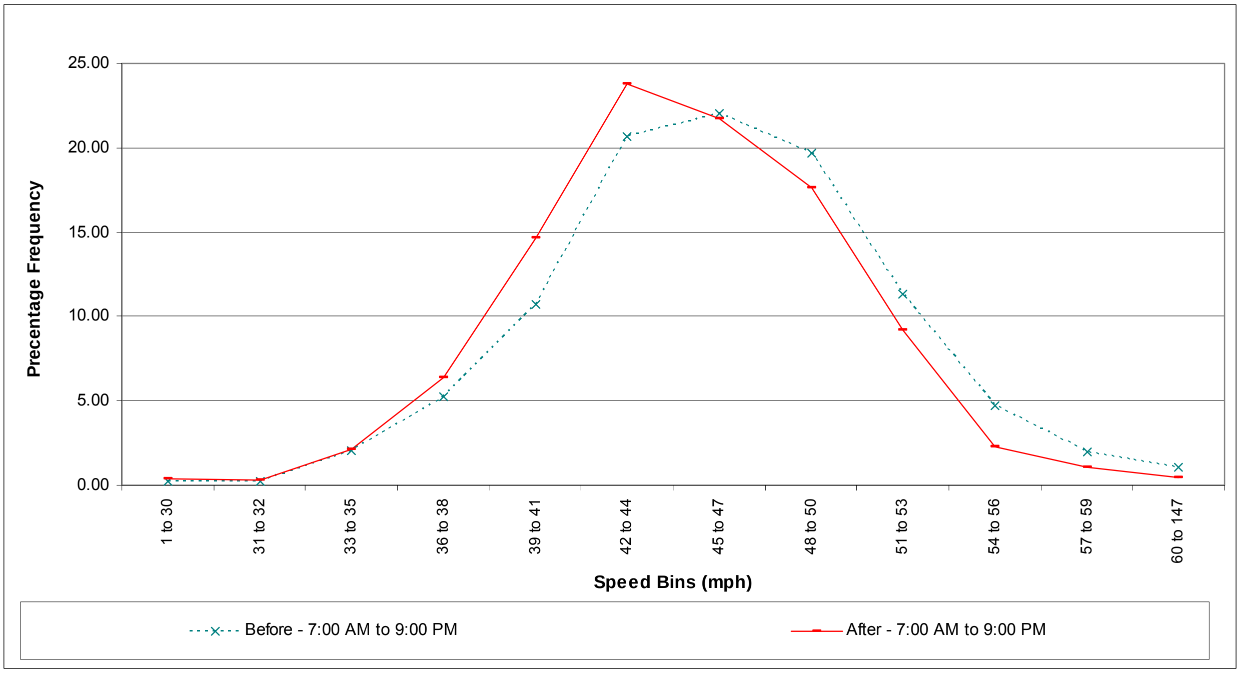


Figure 5-47: Before and After PC Speeds Wkday TOD 7AM-9AM Percentage Frequency

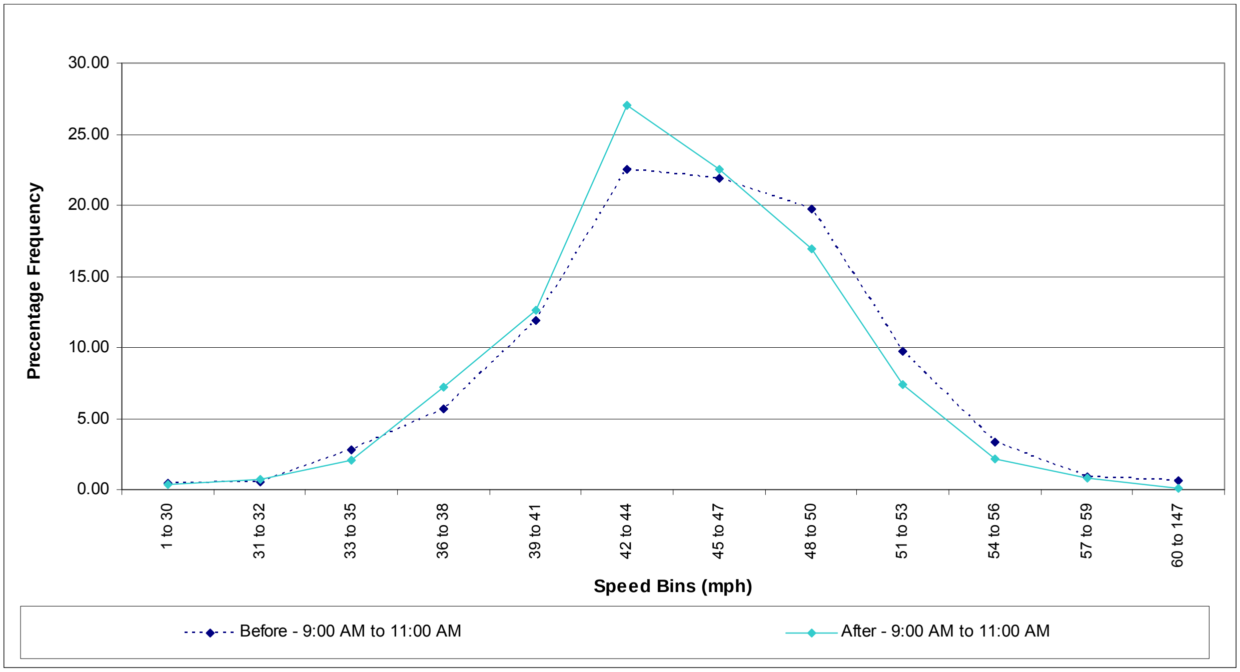


Figure 5-48: Before and After PC Speeds Wkday TOD 9AM-11AM Percentage Frequency

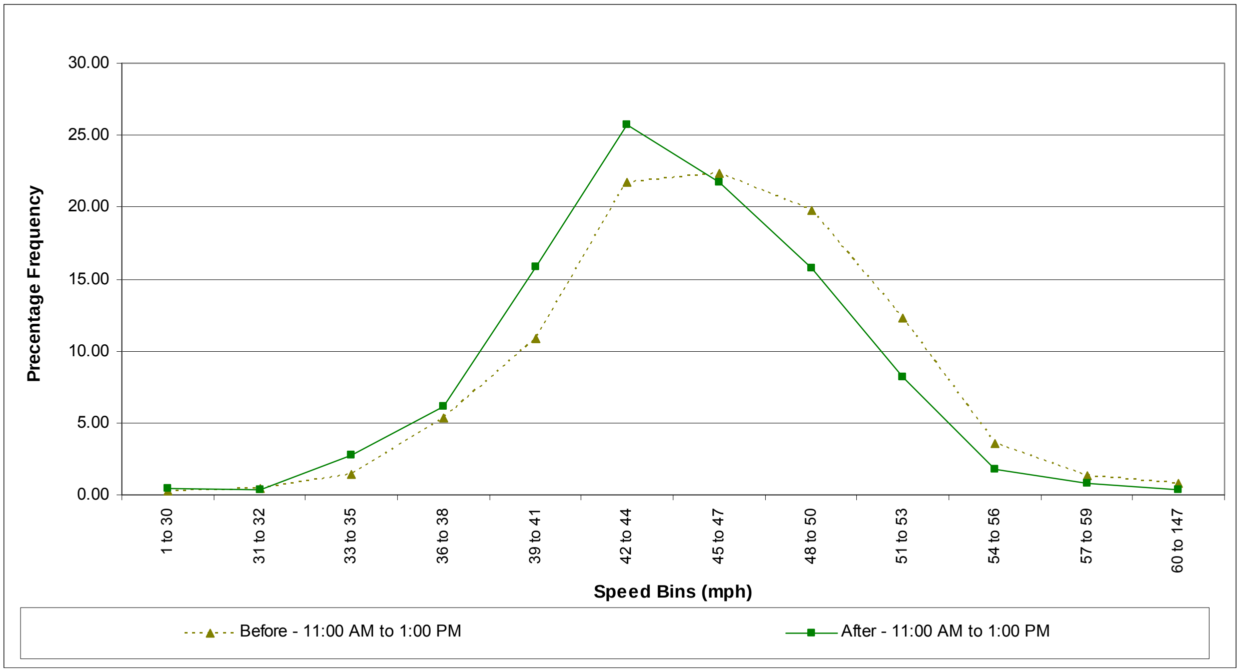


Figure 5-49: Before and After PC Speeds Wkday TOD 11AM-1PM Percentage Frequency

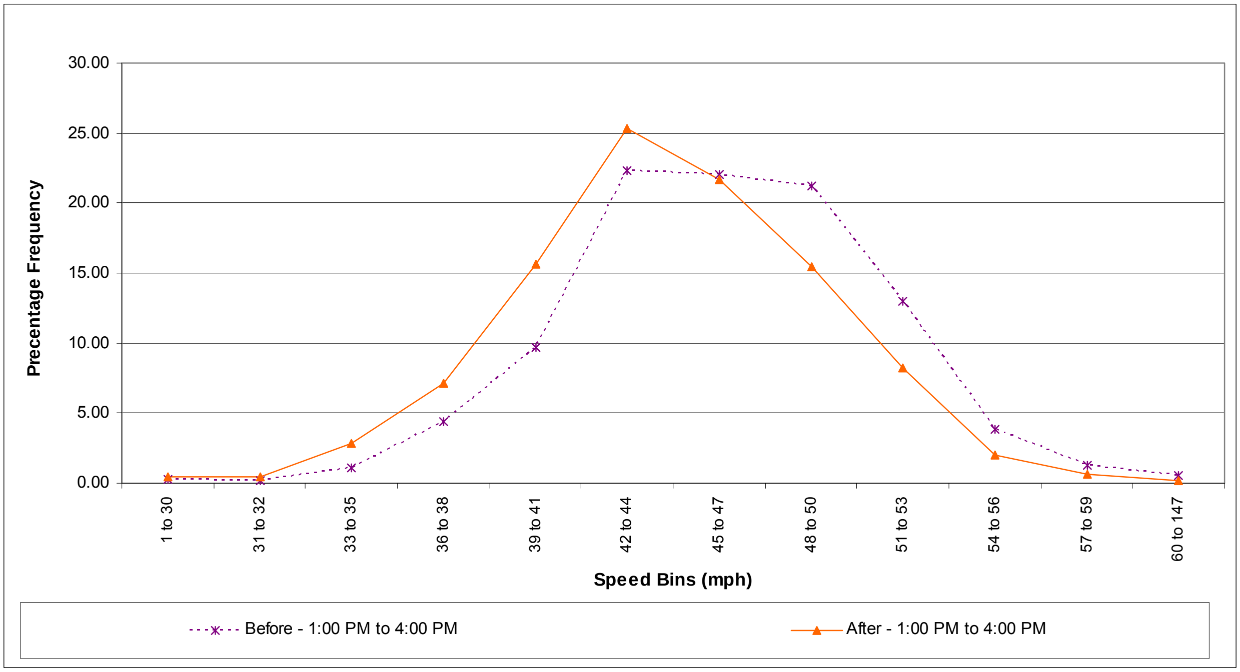


Figure 5-50: Before and After PC Speeds Wkday TOD 1PM-4PM Percentage Frequency

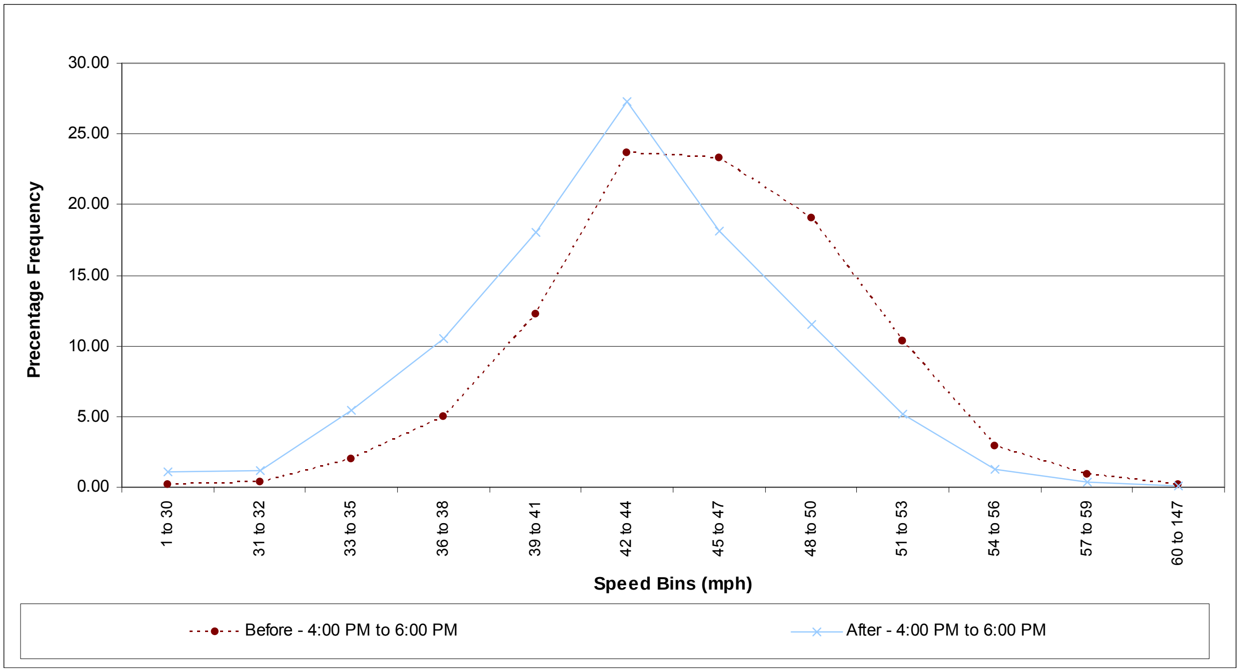


Figure 5-51: Before and After PC Speeds Wkday TOD 4PM-6PM Percentage Frequency

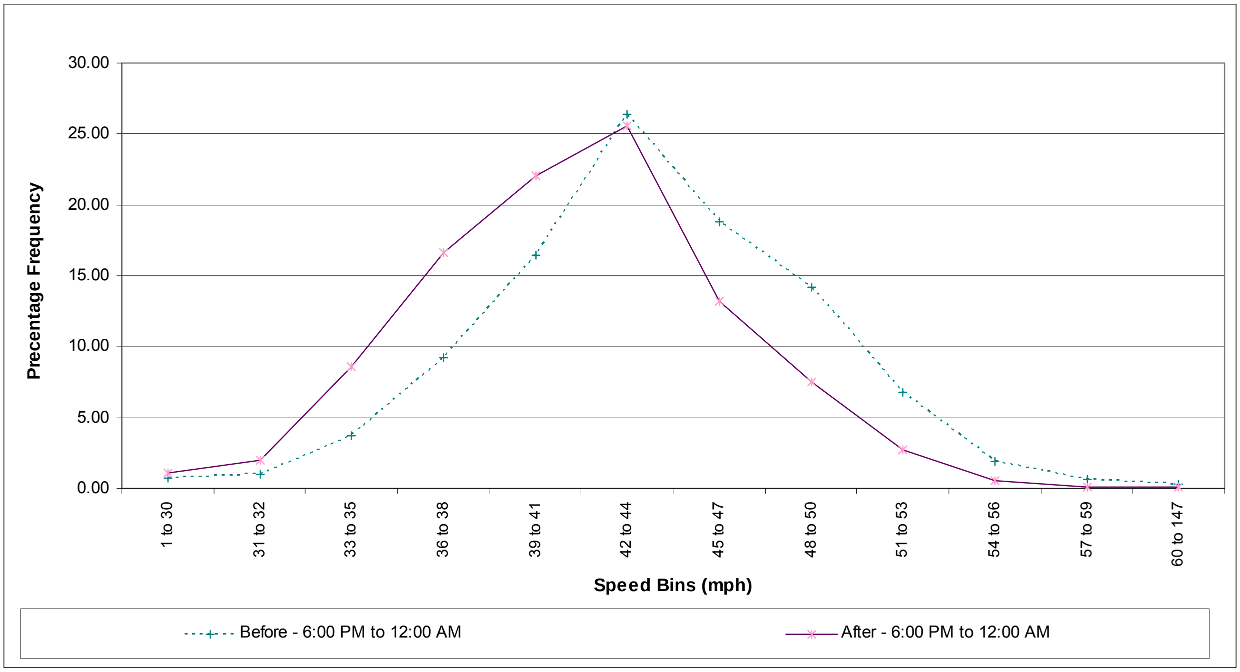


Figure 5-52: Before and After PC Speeds Wkday TOD 6PM-12AM Percentage Frequency

5.2.6 Weekend TOD Data Set - Before and After PC Speeds

Table 5-26 presents the Before and After data and statistical parameters for the PC speeds Weekend Time of Day data sets. Table 5-27 presents the summary of the hypothesis tests results. Figure 5-53 to Figure 5-59 provides frequency graphs of the Before and After speeds for the data sets.

From Table 5-27 it can be seen that generally the both the speed mean and variance reduction was not significant (at the 95 % confidence level). Mean reduction was not significant during the 12 AM to 7 AM, 7 AM to 9 AM, and 9 AM to 11 AM time periods. Variance was not significantly reduced during the 7 AM to 9 AM, 9 AM to 11 AM, 1 PM to 4 PM, 4PM to 6 PM, and 6 PM to 12 AM time periods.

Table 5-26: Before and After PC Speeds Weekend TOD Data Set Summary

Speed (mph)	Before TOD Vehicle Frequency								After TOD Vehicle Frequency							
	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total	12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM	Total
1 to 30	27	0	2	6	8	12	45	**100**	12	1	1	4	9	7	61	**95**
31 to 32	33	1	2	10	8	8	64	**126**	31	4	5	4	14	33	119	**210**
33 to 35	104	12	16	43	50	44	286	**555**	109	13	26	35	85	75	534	**877**
36 to 38	183	33	53	84	140	163	710	**1366**	188	47	75	95	231	249	927	**1812**
39 to 41	259	92	119	179	353	349	1309	**2660**	301	83	221	250	427	461	1394	**3137**
42 to 44	293	155	272	375	702	645	1665	**4107**	379	136	286	372	705	613	1453	**3944**
45 to 47	177	125	237	315	621	476	1060	**3011**	202	162	220	286	484	372	793	**2519**
48 to 50	112	115	174	181	494	347	612	**2035**	143	97	125	226	367	253	424	**1635**
51 to 53	48	61	108	83	215	154	233	**902**	68	58	73	82	176	123	180	**760**
54 to 56	13	23	15	22	58	37	63	**231**	27	10	11	21	49	26	42	**186**
57 to 59	7	12	12	4	18	11	20	**84**	8	9	4	4	10	12	17	**64**
60 to 147	2	2	1	1	8	0	6	**20**	6	4	4	2	6	5	5	**32**
Total	**1258**	**631**	**1011**	**1303**	**2675**	**2246**	**6073**	**15197**	**1474**	**624**	**1051**	**1381**	**2563**	**2229**	**5949**	**15271**
Ave Speed (mph)	**41.62**	**45.41**	**45.21**	**44.13**	**44.99**	**44.24**	**42.64**	—	**42.37**	**44.95**	**43.88**	**44.13**	**43.92**	**43.13**	**41.39**	—
Variance	**33.34**	**26.31**	**22.49**	**23.27**	**23.27**	**22.77**	**24.63**	—	**31.64**	**27.12**	**22.55**	**22.29**	**25.58**	**25.55**	**26.61**	—
Coefficient of Variance	**0.14**	**0.11**	**0.10**	**0.11**	**0.11**	**0.11**	**0.12**	—	**0.13**	**0.12**	**0.11**	**0.11**	**0.12**	**0.12**	**0.12**	—
% Obeying Advisory Speed	**13.04**	**2.06**	**1.98**	**4.53**	**2.47**	**2.85**	**6.50**	—	**10.31**	**2.88**	**3.04**	**3.11**	**4.21**	**5.16**	**12.00**	—
% Obeying Advisory Speed + 5 Mph	**48.17**	**21.87**	**18.99**	**24.71**	**20.90**	**25.65**	**39.75**	—	**43.49**	**23.72**	**31.21**	**28.10**	**29.89**	**37.01**	**51.02**	—
% Obeying Advisory Speed + 10 Mph	**71.46**	**46.43**	**45.90**	**53.49**	**47.14**	**54.36**	**67.17**	—	**69.20**	**45.51**	**58.42**	**55.03**	**57.39**	**64.51**	**75.44**	—
85th Percentile (mph)	**44.00**	**49.00**	**47.00**	**47.00**	**47.00**	**47.00**	**46.00**	—	**46.00**	**47.00**	**46.00**	**47.00**	**47.00**	**46.00**	**44.00**	—

Table 5-27: Before and After PC Speeds Weekend TOD Data Hypothesis Tests

Hypothesis Test	Alternate Hypothesis	Significant?						
		12:00 AM to 7:00 AM	7:00 AM to 9:00 PM	9:00 AM to 11:00 AM	11:00 AM to 1:00 PM	1:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 12:00 AM
Means	μ (b) - μ (a) > 0	No	No	Yes	No	Yes	Yes	Yes
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	No	No	Yes	No	No	No
% Obeying Advisory Speed	P (b) - P (a) < 0	No	No	No	No	Yes	Yes	Yes
% Obeying Advisory Speed + 5 Mph	P (b) - P (a) < 0	No	No	Yes	Yes	Yes	Yes	Yes
% Obeying Advisory Speed + 10 Mph	P (b) - P (a) < 0	No	No	Yes	No	Yes	Yes	Yes

Advisory speed compliance and reduction in the proportion of vehicles in the higher speed ranges was not generally seen to be significant. The lack of significant reduction indicates that the impact of the DSM system on PC curve speeds during the weekend was not very dramatic. From the graphs it was seen that the After distribution of speeds generally still shifted slightly to the lower speed bins as compared to the Before speeds.

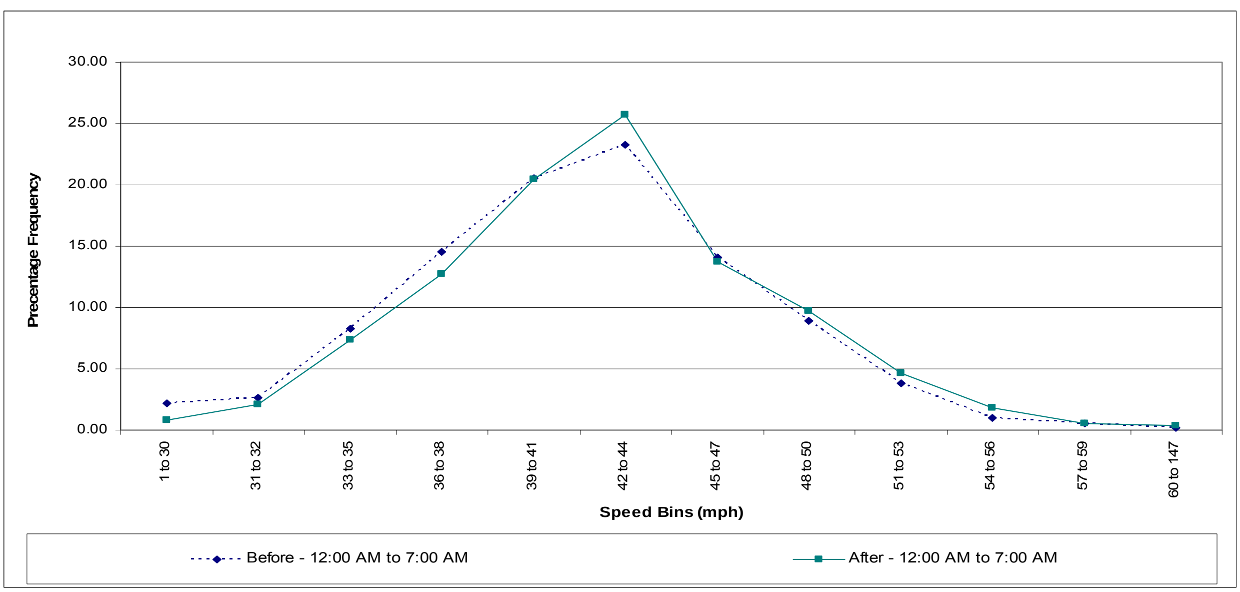


Figure 5-53: Before and After PC Speeds Wkend TOD 12AM-7AM Percentage Frequency

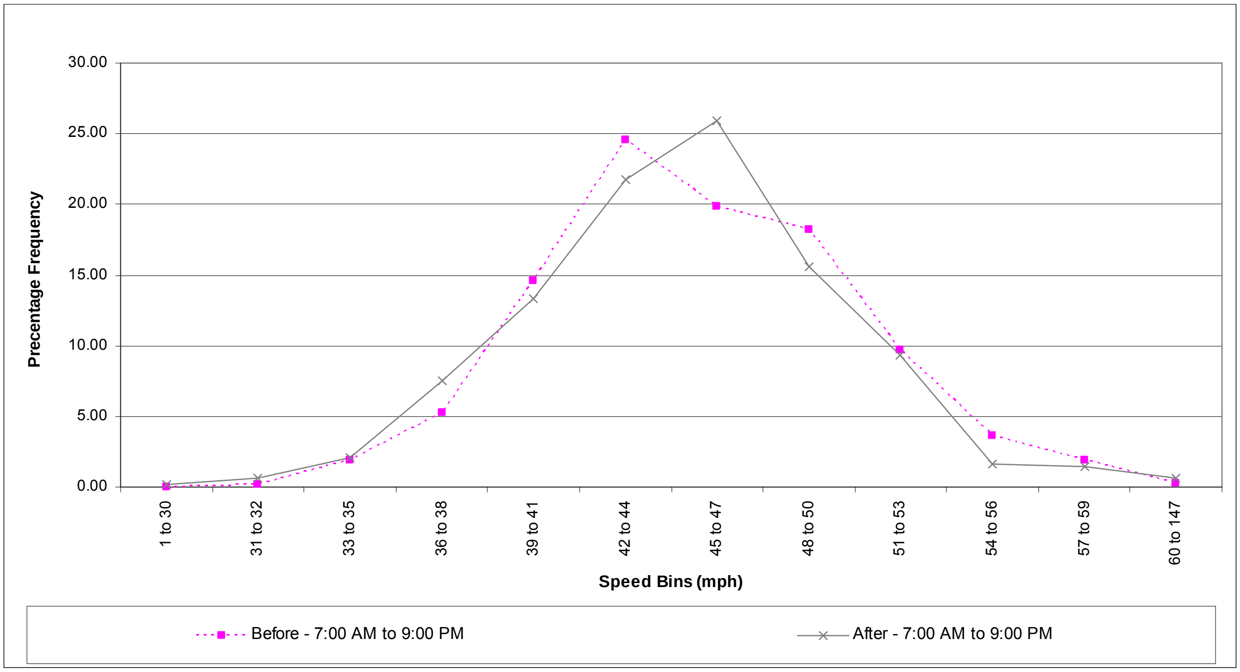


Figure 5-54: Before and After PC Speeds Wkend TOD 7AM-9AM Percentage Frequency

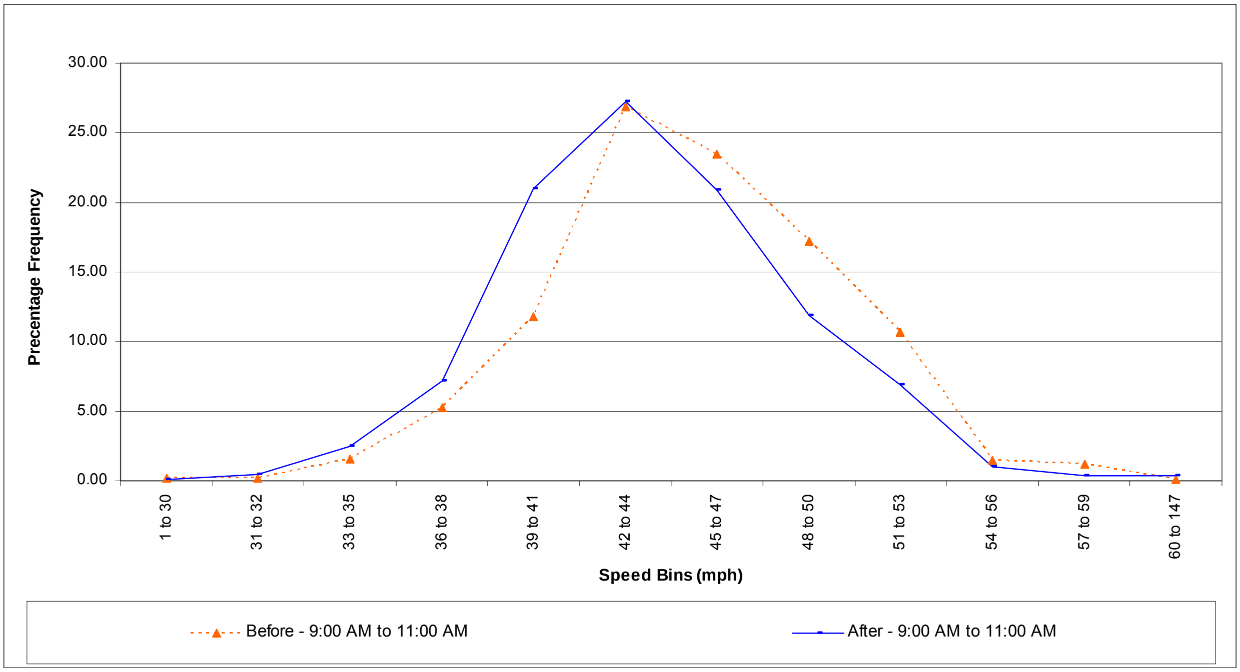


Figure 5-55: Before and After PC Speeds Wkend TOD 9AM-11AM Percentage Frequency

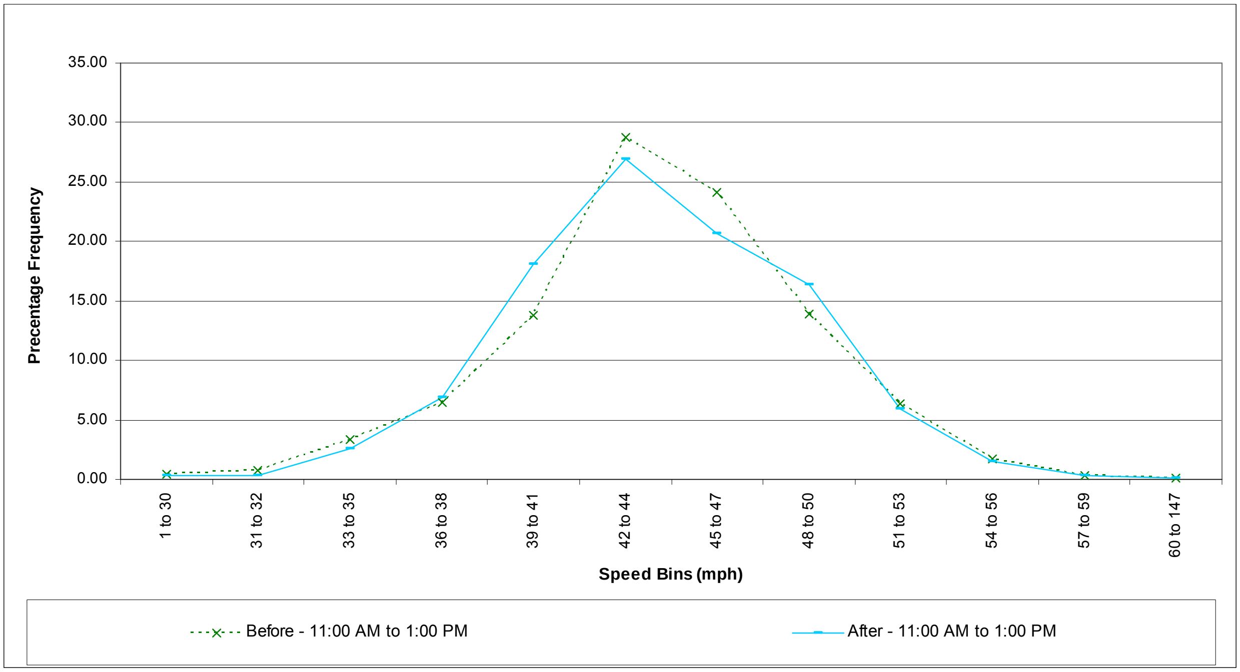


Figure 5-56: Before and After PC Speeds Wkend TOD 11AM-1PM Percentage Frequency

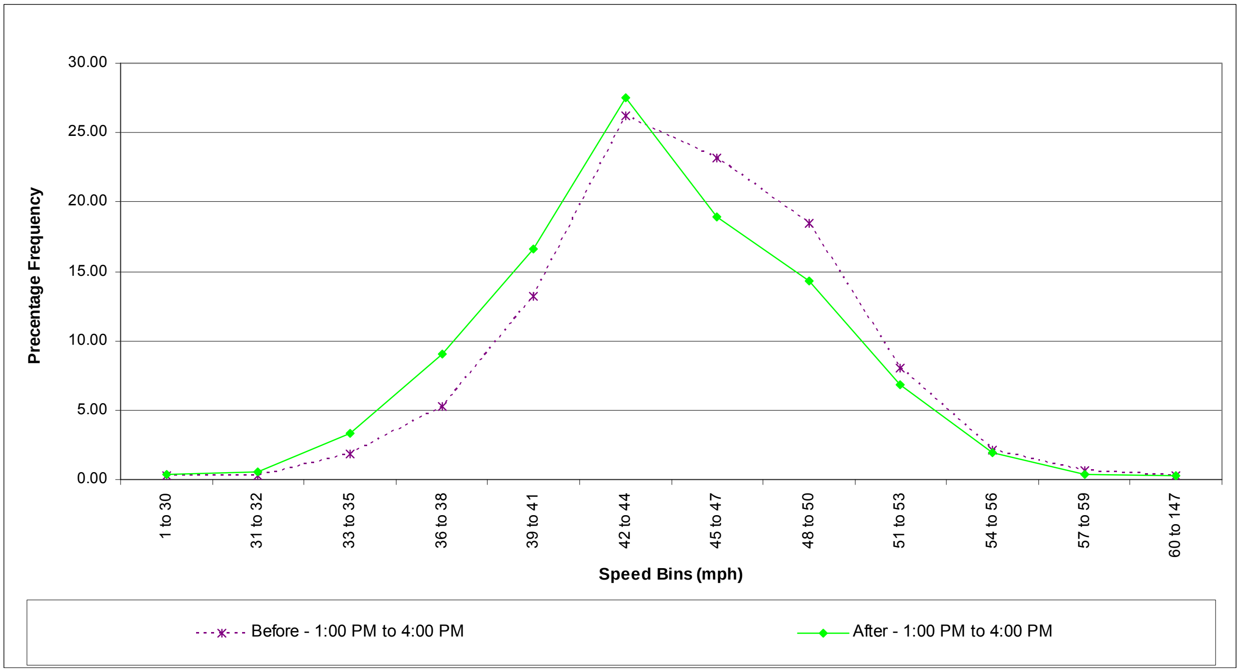


Figure 5-57: Before and After PC Speeds Wkend TOD 1PM-4PM Percentage Frequency

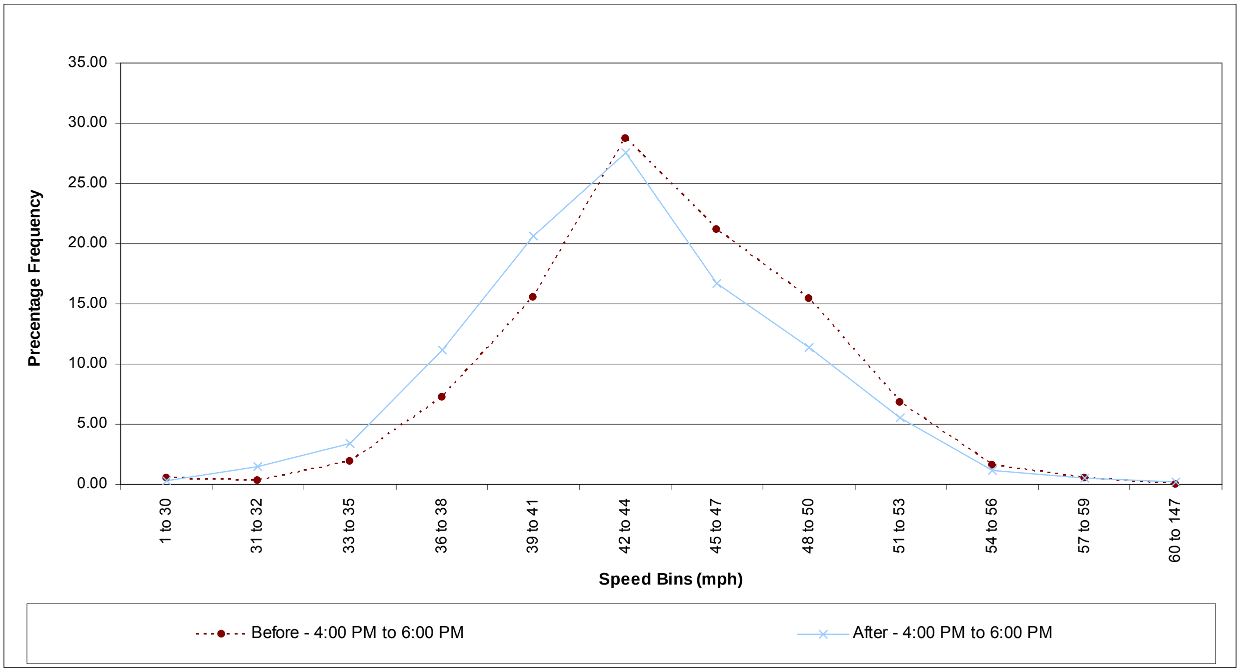


Figure 5-58: Before and After PC Speeds Wkend TOD 4PM-6PM Percentage Frequency

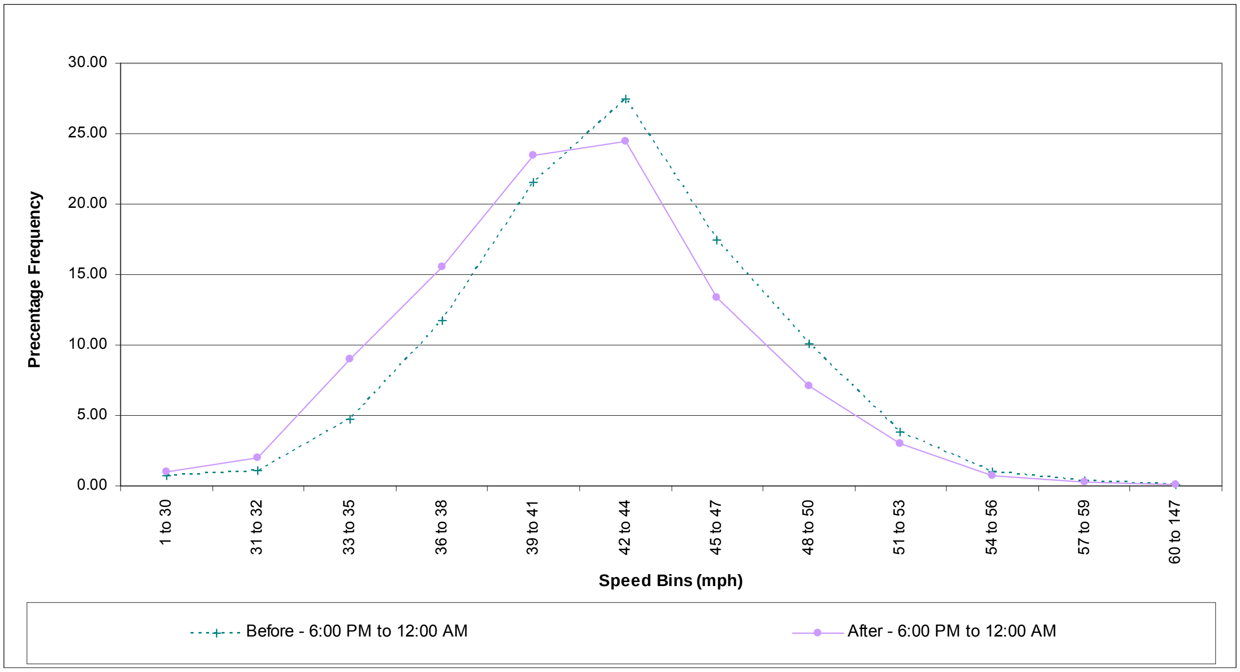


Figure 5-59: Before and After PC Speeds Wkend TOD 6PM-12AM Percentage Frequency

5.2.7 Speed Range Data Set - Before and After PC Speeds

Table 5-28 presents the Before and After data and statistical parameters for the Speed Range PC data sets. Table 5-29 presents the hypothesis tests results. Figure 5-60 and Figure 5-61 illustrate graphically the variation in the Before and After frequency and means respectively.

Table 5-29 shows that generally the speed mean reduction was significant except for the 1 to 35 mph and 36 to 47 mph ranges. The mean speed in the 1-35 speed range was not significantly reduced because vehicles, originally traveling in the higher speed bins, were slowing down to within the 1 to 35 speed range thus causing this increase in mean speed. Also, the mean speed in the 60 to 147 speed range was not significantly reduced because, as more vehicles utilized the lower speed bins, the remaining vehicles in the 60 to 147 range were those that traveled at higher speeds.

Table 5-28: Before & After PC Speed Ranges Data Set Summary

Parameters	Speed Ranges Bins				
	1 to 35	36 to 47	48 to 59	60 to 147	Total
BEFORE					
Frequency	2977	40082	15423	197	58679
Average Speed (mph)	32.25	42.41	50.72	62.26	---
Variance	10.13	8.78	5.46	5.56	---
Coefficient of Variance	0.10	0.07	0.05	0.04	---
Proportion	0.051	0.683	0.263	0.003	1.000
AFTER					
Frequency	5308	43195	10289	89	58881
Average Speed (mph)	32.64	41.87	50.49	62.04	---
Variance	7.58	9.25	4.75	4.94	---
Coefficient of Variance	0.08	0.07	0.04	0.04	---
Proportion	0.090	0.734	0.175	0.002	1.000

Table 5-29: Before & After PC Speed Ranges Data Hypothesis Tests

Hypothesis Test	Alternate Hypothesis	Significant?			
		1 to 35	36 to 47	48 to 59	60 to 147
Means	μ (b) - μ (a) > 0	No	Yes	Yes	No
Variance	σ^2 (b) / σ^2 (a) > 0	Yes	No	Yes	Yes
Lower Speed Range Proportion	P (b) - P (a) < 0	Yes	Yes	---	---
Higher Speed Range Proportion	P (b) - P (a) > 0	---	---	Yes	Yes

The speed variance in the 36 to 47 mph speed range was not significantly reduced potentially because as the distribution of all the speeds shifted to the lower speed bins there were more vehicles traveling at the lower and upper speeds of this speed range. It can also be seen that the increase in proportion of vehicles in the lower speed ranges and the decrease in proportion of vehicles in the upper speed ranges was significant. Numerically and from the graphs it was seen that the After distribution of speeds generally shifts to the lower speed bins as compared to the Before speeds. More vehicles traveled in the lower speed ranges and less traveled in the upper speed ranges as shown in Figure 5-60.

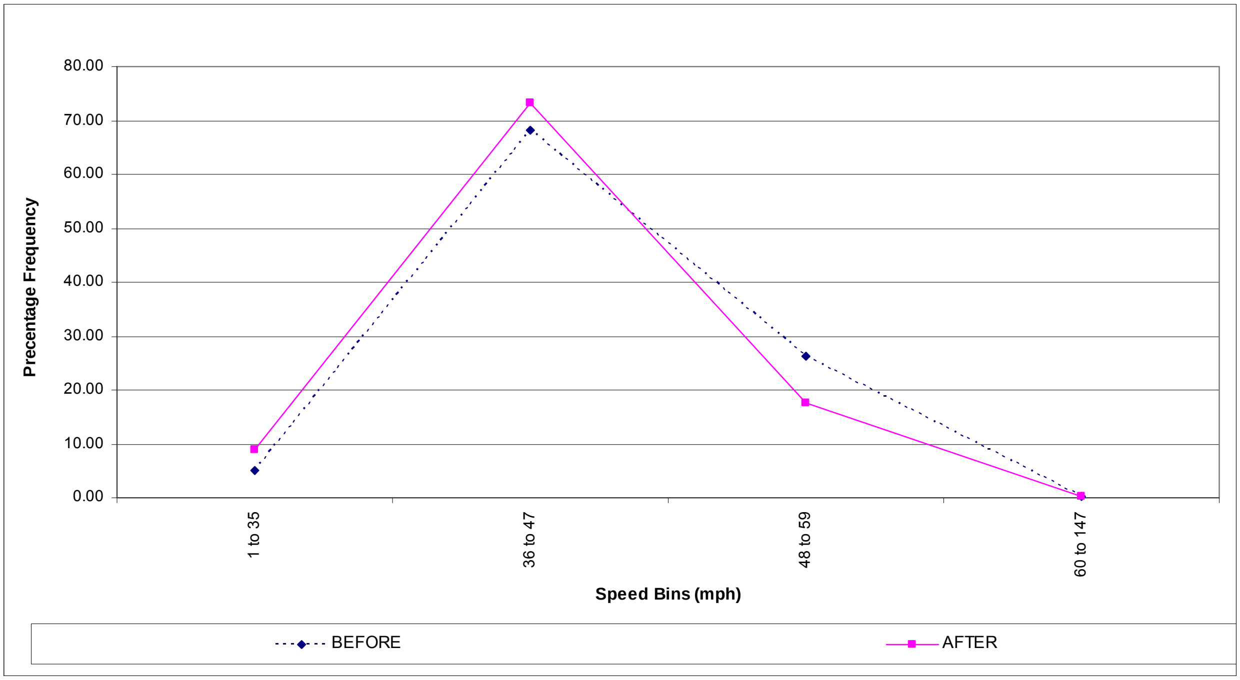


Figure 5-60: Before & After PC Speed Ranges Percentage Frequency Graph

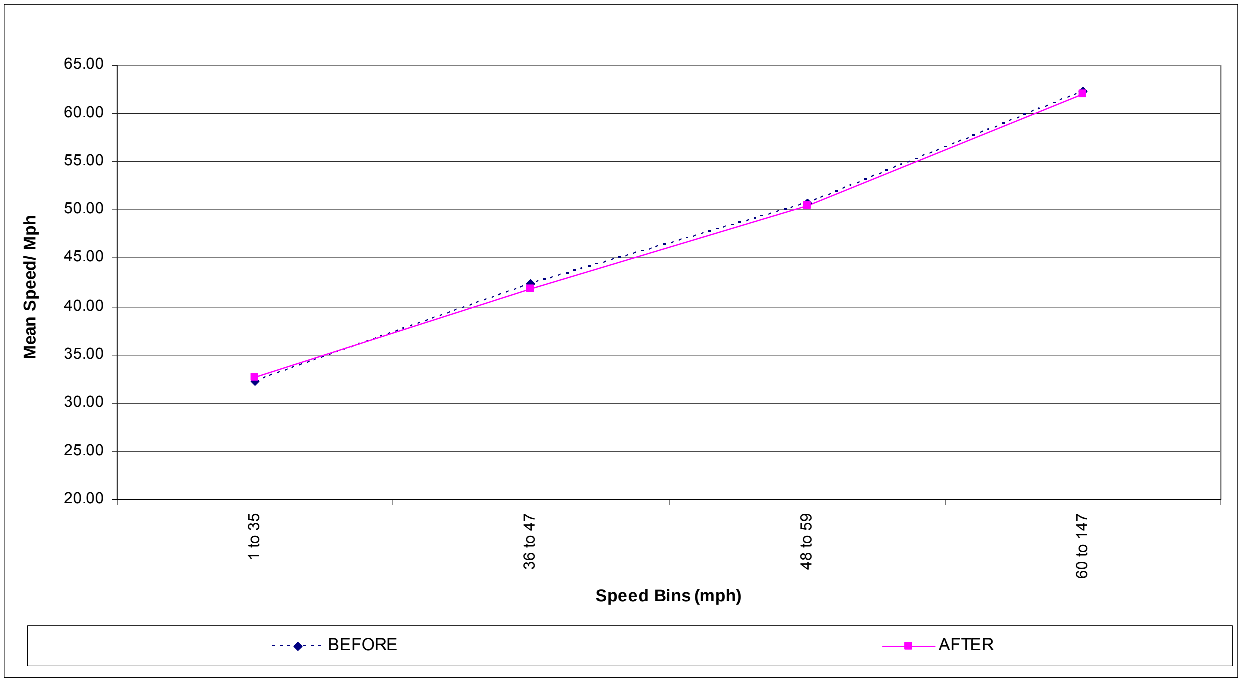


Figure 5-61: Before & After PC Speed Ranges Mean Graph

5.2.8 Higher Speed Range Data Set - Before and After PC Speeds

Table 5-30 presents the speed data for the higher speed ranges (45 mph and greater) of the PC data set. The table shows the percentage reduction in the proportion of vehicles in the higher speed ranges was 14% or greater. As the speed range increased the reduction percentage also increased as shown in Figure 5-62. Figure 5-63 shows the before and after proportion of vehicles in the higher speed ranges and illustrates visually the reduction.

Table 5-30: Before & After PC Higher Speed Ranges Data Set Summary

Speed Bins (> 45 mph only)	Before		After		Percentage Reduction in Proportion of Vehicles in Speed Range
	Percentage of Total Data Collected	Frequency	Percentage of Total Data Collected	Frequency	
45 to 47	19.339	11348	16.586	9766	14.2%
48 to 50	15.189	8913	10.846	6386	28.6%
51 to 53	7.977	4681	5.005	2947	37.3%
54 to 56	2.296	1347	1.223	720	46.7%
57 to 59	0.821	482	0.401	236	51.2%
60 to 147	0.336	197	0.151	89	55.0%

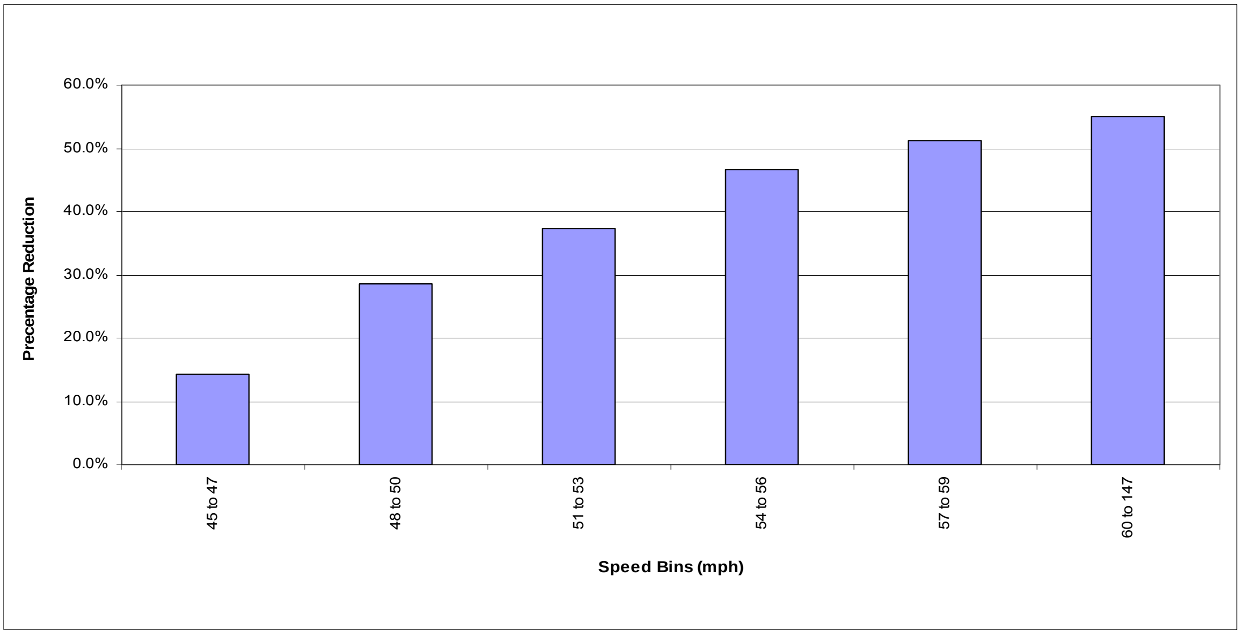


Figure 5-62: Before & After PC Speeds - Percentage Reduction in Proportion of Vehicles in Higher Speed Range

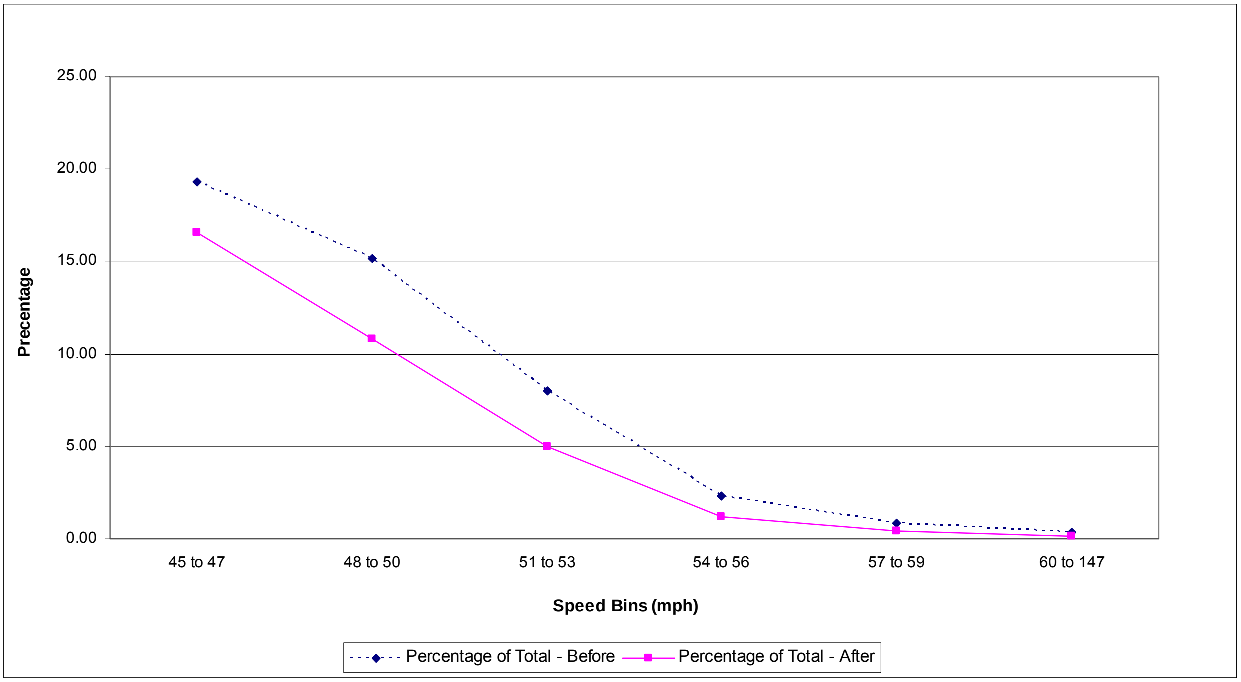


Figure 5-63: Before & After PC Speeds Percentage of Vehicles in Higher Speed Range

6 SUMMARY

The summary of the analysis results for this thesis have been divided into the following five sections based upon the data analyzed.

6.1 Crash Data Analysis

The interchange crash data indicated that there was clearly an overturning crash problem at the US 27/US 192 interchange since the largest percentage (approximately 50%) of the crashes were of that type. Investigations into all the overturned crashes that occurred at the interchange indicated that most of the crashes, 75%, were due to careless driving or motorists exceeding the speed limit. More of the overturned crashes also occurred on the weekend than did on weekdays. The data also indicated that 56% of all the crashes at the interchange occurred on the SB entry study ramp. For the overall interchange no specific growth rate was seen but the average crashes per year in the years 2002 to 2004 was higher (14.33) than that from the years 1996 to 2001 (8.67).

The southbound entry study ramp followed similar trends as the total interchange data in terms of crash type and contributing cause. The majority of the crashes, 56%, were overturned crashes. Most of the crashes, 74%, were due to careless driving or motorists exceeding the speed limit. Crashes occurred in approximately equal percentages during the day and night and dry or wet conditions. There were approximately equal percentages of property damage only and injury crashes. Crashes on the study ramp decreased from 2000 onwards and this coincided with the milling and resurfacing and signage improvements completed in that year.

The high prevalence of overturning crashes confirmed that the southbound entry study ramp was prone to vehicle off-tracking. More crashes occurred during the day than at night and was most likely because there was a greater volume during the day hence increasing the chances of a crash occurring. Crashes did not seem to be influenced by rainy conditions (wet or dry). The majority of the south bound crashes were due to motorists exceeding the speed limit or careless driving and therefore implementation of a DSM system could potentially improve safety by reducing speeds and acting as a visual stimulus to increase driver attentiveness.

6.2 Geometric Data Analysis

The geometric data analysis revealed that the southbound entry study ramp was comprised of a two radii compound cure with the preceding curve having a radius of 500 feet and the following curve having a radius of 300 feet. The curves met AASHTO guidelines for the ratio of flatter curve to sharper curve and desirable arc length. However the 300 foot following curve is more applicable for a posted advisory speed of 25 mph as opposed to the 35 mph advisory speed currently posted. In addition, the interchange bridge acts to "hide" the curve from approaching drivers and drivers may not generally receive a roadway alignment stimulus to warn of the curve until passing under the bridge. Also, the interchanging roadways are higher speed roadways (speed limit 55 mph) and motorist may tend to try to maintain their high speed while navigating the curve. It was concluded that a combination of these three factors contributed to the high prevalence of vehicle off tracking seen at the interchange.

6.3 Rainfall Data Analysis

The rainfall analysis was conducted in support of the Before and After speed data analysis. That is, since drivers tend to drive slower when it is raining, if either the Before or After condition was significantly more rainy than other, then the speed reduction observed would not be representative of the effect of the DSM system. Although data was not available for the actual study site, rain data was obtained from a weather station located 10 miles away. This data was deemed applicable because the occurrence of a rainfall event in Polk County, Florida was moderately correlated at short distances (0 to 28 miles). Mean daily rainfall for the Before and After data sets for both the Approach and PC speed data collection days were compared and the initial After data sets for both conditions were found to be significantly more rainy (at the 95% confidence level). The rainy days (days with greater than 0.5 inches of rainfall) in the initial After data sets were then further investigated, using 10 minute daily rainfall data, to determine the possible time period that the rain event occurred (day AM, day PM, night AM, night PM). These rainy time periods were replaced with speed data from a similar time period during a non-rainy day (to the extent possible due to data limitations). The means of the Before and resulting After data set were then again compared (at the 95% confidence level) and were found to not be significantly different. These data sets were used for the speed data analysis and any speed reduction observed in the After condition were considered to be free from influence by large rain storms.

6.4 Approach Speed Data Analysis

The study evaluated the eight (8) data sets; Entire data set, Day/ Night time data set, Daily data sets, Time of Day or TOD data sets, Weekdays TOD data set, Weekend TOD data set, Speed Ranges data set, and Higher Speed Ranges data sets. The parameters evaluated were the Before and After speed mean, variance, proportion of vehicles obeying the speed limit, proportion of vehicles obeying the speed limit + 5 mph, proportion of vehicles obeying the speed limit + 10 mph, proportion of vehicles in speed range (for speed range data sets only), the 85th percentile, and coefficient of variation.

The DSM system produced a significant reduction in mean speeds and variance for almost all the data sets except for a few sets associated with weekends, late night and early morning periods in which variance was not reduced. The proportion of vehicles obeying the speed limit increased for all the data sets. There was reduction in the 85th percentile speed (61 to 57 mph) and the coefficient of variation (approximately 0.13) remained relatively unchanged. The fact that the coefficient of variation remained unchanged indicated that there was a decrease in both mean and variance. In general, there was a clear shift of the speed distribution from the higher speed bins to the lower speed bins. The major findings of each of the data parameters are discussed in the following paragraphs.

The DSM system was found to significantly reduce (at the 95% confidence level) the mean Approach speeds for all the data sets. For the entire data set, mean speed was reduced by 3.52 mph and the reduction was similar during the day and night (3.56 and 3.64 mph respectively). In general, the mean speed reduction was similar during both the weekdays and weekends (3.45 and 3.66 mph). The mean speed in the 1 to 35 speed range was not significantly reduced because vehicles, originally traveling in the higher speed bins, were slowing down to within the 1 to 35 speed range thus causing an increase in the mean speed of this speed range.

The Approach speeds variance was found to be significantly reduced (at 95% confidence level) for most of the data sets. Variance reduction was not significant on Tuesday, between the 12 AM to 7 AM time interval, between 6 PM to 12 AM on weekdays, and been 12 AM to 7 AM on weekends. For the entire data set, speed variance was reduced by 3.34. The variance increased by 4.88 and decreased by 0.28 during the day and night time respectively. Speed variance decreased during the weekdays and weekends by 2.72 and 2.10 respectively, suggesting that when there are lower volumes and when motorists' perception that speed limit enforcement is not as likely (on the weekend) the DSM system effectiveness is slightly reduced. The speed variance in the 36 to 47 mph speed range was not significantly reduced. This was potentially because as the distribution of all the speeds shifted to the lower speed bins there were more vehicles traveling at the lower and upper speeds of this speed range.

The DSM system effectiveness in increasing the proportion of vehicles complying with the speed limit was significant (at the 95% confidence level) for all data sets. The DSM system effectiveness in increasing the proportion of vehicles complying with the speed limit + 5 mph and speed limit + 10 mph was also significant (at the 95% confidence level) for all data sets. The proportion of motorist who complied with the speed limit increased from 55.95% to 78.22% an increase of approximately 23 %.

The DSM system was effective in reducing the proportion of vehicles in the high speed ranges (57 mph and greater). There was a large percentage reduction in the proportion of vehicles that utilized these speed ranges and the reduction increased as the speed range increased. There was a 42% reduction in the vehicle using the 57 to 59 speed range and a 74% reduction in the vehicles utilizing the greater than 69 mph speed range.

6.5 PC Speed Data Analysis

The study evaluated the eight (8) data sets; Entire data set, Day/ Night time data set, Daily data sets, Time of Day or TOD data sets, Weekdays TOD data set, Weekend TOD data set, Speed Ranges data set, and Higher Speed Ranges data sets. The parameters evaluated were the Before and After speed mean, variance, proportion of vehicles obeying the advisory speed, proportion of vehicles obeying the advisory speed + 5 mph, proportion of vehicles obeying the advisory speed + 10 mph, proportion of vehicles in speed range (for speed range data sets only), the 85th percentile, and coefficient of variation.

The DSM system generally produced a significant reduction (at the 95% confidence level) in mean speeds and variance for most of the data sets except those associated with weekends, late night or early morning periods. The reduction in proportion of vehicles obeying the advisory speed + 5 mph and advisory speed + 10 mph was greater than the reduction in proportion of vehicles obeying the advisory speed. This indicated that most motorists utilized a speed above the advisory speed of 35 mph to navigate the curve. There was only a small reduction in the 85^{th} percentile speed (47 to 46 mph) and the coefficient of variation (approximately 0.12) remained relatively unchanged. The fact that the coefficient of variation remained unchanged indicated that there was a decrease in both mean and variance. In general, there was a clear shift of the speed distribution from the higher speed bins to the lower speed bins. The major findings of each of the data parameters is discussed in the following paragraphs.

The DSM system was found to significantly reduce (at the 95% confidence level) the mean PC speeds for all the data sets except the late night, early morning and midday (12 AM to 7 AM, 7

AM to 9 AM and 11 AM to 1 PM) weekend periods. For the entire data set, mean speed was reduced by 1.57 mph and the reduction was greater during the day than at night (1.74 and 1.05 mph respectively). In general, the mean speed reduction was greater during the weekdays (1.94 mph) than during weekends (0.90 mph). The mean speed in the 1-35 speed range was not significantly reduced because vehicles, originally traveling in the higher speed bins, were slowing down to within the 1 to 35 speed range thus causing an increase in the mean speed of this speed range. Also, the mean speed in the 60 to 147 speed range was not significantly reduced because, as more vehicles utilized the lower speed bins, the remaining vehicles in the 60 to 147 range were those that traveled at higher speeds.

The PC speeds variance was found to be significantly reduced (at 95% confidence level) for some of the data sets. Variance reduction was not significant during the day time, on Monday and Sunday, between the 1 PM to 4 PM and 4 PM to 6 PM time intervals for all the data, between 4 PM to 6 PM on weekdays, and been 7 AM to 9 AM, 9 AM to 11 AM, 1 PM to 4 PM, 4 PM to 6 PM, and 6 PM to 12 PM on weekends. For the entire data set, speed variance was reduced by 0.70. The variance increased by 0.82 and decreased by 2.48 during the day and night time respectively. This indicated that the DSM system was more effective at night in reducing variance of PC speeds. This is contrary to what was seen with the Approach data in which variance reduction was less at night. This indicates that during the night, even though the initial approach variance was high, the DSM system encouraged variance reduction as vehicles entered the curve. This could be due to the fact that the sign is very visible at night as it was the only illuminating source at the rural unlit interchange. Speed variance decreased during the weekends (0.57) and increased during the weekends (1.69) suggesting that when there are lower volumes and when motorists' perception that speed limit enforcement is not as likely (on the weekend) the DSM system effectiveness is reduced. The speed variance in the 36 to 47 mph speed range was not significantly reduced. This was potentially because as the distribution of all the speeds shifted to the lower speed bins there were more vehicles traveling at the lower and upper speeds of this speed range.

The DSM system effectiveness in increasing the proportion of vehicles complying with the advisory speed was not significant (at the 95% confidence level) for some of the data sets and in general the proportion of motorists complying with the advisory speed of 35 mph was low (less than 10%). This indicated that motorist utilized speeds in excess of the advisory speed to navigate the curve. With the implementation of the DSM system, the increase in the proportion of motorists who drove at the advisory speed or less was not increase by more that 5%. However the proportion of motorist who drove at the advisory speed + 5 mph (40 mph) and the advisory speed + 10 mph was increased (45 mph) significantly increased (at the 95% confidence level) by 11.56% and 11.75% respectively. The increase in the proportion of vehicles in the advisory speed + 5 mph and the advisory speed + 10 mph was not increased significantly during the 12 AM to 7 AM and 7 AM to 9 AM weekend time periods. As seen in the variance analysis, this suggested that, that when there are lower volumes and when motorists' perception that speed limit enforcement is not as likely (as on the weekend) the DSM system effective is reduced.

The DSM system effectiveness in reducing the proportion of vehicles in the high speed ranges (45 mph and greater) indicated that there was a large percentage reduction in the proportion of vehicles that utilized these speed ranges and the reduction increased as the speed range increased. There was a 14% reduction in the vehicle using the 45 to 47 speed range and a 55% reduction in the vehicles utilizing the greater than 60 mph speed range. This suggested that DSM system was effective in reducing high speed vehicles.

7 CONCLUSIONS

The objective of this thesis was to test the effectiveness of a DSM system at reducing vehicle speeds at the rural US 27/ US 192 trumpet interchange in Polk County, Florida. The system tested was a solar powered, radar based, wireless speed warning system which potentially could be used at traffic locations where it is difficult to secure power and to extended wires. The Measures of Effectiveness (MOEs) for the system were the reduction in mean and variance of speed along with the proportion of vehicles in the higher speed ranges after system implementation. This thesis described the testing of the DSM effectiveness and involved the documentation of the experiments conducted, the data collected and the analysis of the results.

Speed data was collected Before and After installation of the DSM system at two points preceding the southbound entry ramp. Approach speeds were collected at a point 250 feet in advance of the southbound entry ramp curve (also the detection zone of the DSM system radar) and PC speeds were collected at the Point of Curve of southbound entry ramp. Various data sets were analyzed in order to ascertain the systems effectiveness during the day and night, weekdays and weekends, various time periods during the day, and within various speed ranges.

The Approach and PC data analysis indicated that the DSM system significantly (at the 95% confidence level) reduced speed mean and variance and increased speed limit/ advisory speed compliance. The Approach mean speed was reduced by 3.58 mph and the PC mean speed was reduced by 1.57 mph. The Approach speed variance was reduced by 3.34 and the PC speed variance was reduced by 0.70 mph. Approach speed limit compliance was increased by 22.27% and PC advisory speed (35 mph) + 5 mph compliance was increased by 11.56% (it was apparent that motorist were utilizing speeds above the advisory speed to navigate the curve). In general, the effectiveness of the DSM system was diminished on weekends as well as during the late night and early morning (12 AM to 7 AM) time periods. This suggested that when there were lower volumes and when motorists' perceived that speed limit enforcement was not as likely, the DSM system effectiveness was reduced. The DSM system resulted in a reduction in the percentage of vehicles utilizing the higher speed ranges (> 45 mph). There was a 62% average reduction in the vehicles that utilized the speed ranges above 57 mph for the Approach data and there was a 36% average reduction in the vehicles that utilized the speed ranges above 45 mph for the PC data. The DSM system resulted in a shift in the distribution of speeds from the higher speed bins to the lower speed bins Before and After installation.

7.1 Suggested Recommendations

Based on this thesis, the following recommendations are suggested:

1. The posted advisory speed on the southbound entry ramp curve at the US 27/ US 192 interchange should be lowered to 25 mph. The following curve of the two radii compound curve for the loop ramp has a radius of approximately 300 feet. Based on current FDOT design standards (*FDOT, "Florida Greenbook," 2005, Table 3-3*) the 300 foot following curve is more applicable to a posted advisory speed of 25 mph as opposed to the 35 mph advisory speed currently posted.
2. The Dynamic Speed monitoring System (DSM) should be kept in place and maintained. The DSM system currently installed was shown to significantly lower both approaching vehicle speeds as well as speeds of vehicles as they enter the southbound entry loop ramp.

3. In addition, the system should be further evaluated for effectiveness in long term (3 months) situations and at other locations. This is discussed in more in the Section 7.3.

7.2 Limitations

This thesis was limited by the fact that the pneumatic tubes, used to collect speed data at the point of curve (PC) of the southbound entry loop ramp, only provided grouped data. The actual speeds of passing vehicles were placed within certain ranges or groups of 2 mph or greater. The statistical parameters (e.g. calculation of mean and standard deviation) calculated in this thesis using the grouped data would not be as accurate as if the parameters were calculated from discrete speed data.

Another limitation of this thesis was the lack of on-site rainfall data. In general drivers then to drive more slowly when it is raining and in order to test the effectiveness of the DSM system the rainfall condition before and after implementation of the system should be similar. In order to verify that this was the case, rainfall data was used from the closest available weather station located 10 miles away. Although previous research in Florida has showed moderated correlation of rainfall events over such distances, having on-site data would have been more accurate.

Another limitation of this thesis is the potential for incorrect inferences due to the use of the Before and After methodology. In generally, inherent threats to the validity of an effectiveness evaluation exists with a Before and After study. These include history, maturation and regression artifacts which may all tend to inaccurately indicate that a treatment (DSM system in this case) has had a beneficial effect. History is the threat associated with the possibility that specific causes other than the treatment being investigated resulted in all or part of the observed improvement. Maturation is a treat that occurs because the evaluator is unaware of trends since measurements only occur at two points in time. An observed improvement may be a continuation of a downward trend and not specifically an improvement caused by the treatment. Regression artifacts is a threat associated with a regression to the mean of the Before and After data. An improvement may not be due to the treatment but just to a natural downward fluctuation.

7.3 Future Scope

A possible extension of this study is to evaluate the long term effectiveness of the DSM system. Another possible extension is to evaluate the effectiveness of a similar DSM system at other locations. These would involve taking more speed data at monthly intervals after system installation and evaluating the system based on similar Measures of Effectiveness (MOEs) such as the reduction in mean and variance of speed along with the reduction in the proportion of vehicles in the higher speed ranges.

APPENDIX A: CRASH DATA

US 27/ US 192 Interchange - Crash Data Summary

No.	No.	Date	Day	Location	Type	Cause	Day/ Night	Wet/ Dry	Severity
1	1	2/15/1996	Thursday	SB entry	Sideswipe	Improper lane change	Day	Wet	P
2	2	3/9/1996	Saturday	NB exit	Overturned	Exceeded safe speed limit	Day	Dry	I
3	3	5/13/1996	Monday	SB entry	Overturned	Exceeded safe speed limit	Night	Dry	I
4	4	8/9/1996	Friday	SB entry	Overturned	Careless driving	Day	Dry	I
5	5	8/11/1996	Sunday	SB entry	Sideswipe	Exceeded safe speed limit	Day	Wet	P
6	6	9/9/1996	Monday	SB entry	Hit fence	Careless driving	Day	Wet	I
7	7	10/5/1996	Saturday	SB entry	Overturned	Exceeded safe speed limit	Day	Wet	I
8	8	10/6/1996	Sunday	SB entry	Hit fixed object/ Overturned	Careless driving	Day	Wet	I
9	9	12/5/1996	Thursday	SB entry	Overturned	Exceeded safe speed limit	Night	Wet	P
10	1	4/10/1997	Thursday	NB entry	Rear End	Unknown	Night	Unknown	P
11	2	4/14/1997	Monday	SB entry	Jackknifed	Exceeded safe speed limit	Day	Wet	P
12	3	6/1/1997	Sunday	SB entry	Angle	Failed to yield R/W	Day	Wet	P
13	4	6/11/1997	Wednesday	SB entry	Overturned	Exceeded safe speed limit	Day	Dry	P
14	5	7/4/1997	Friday	SB entry	Overturned	Exceeded safe speed limit	Night	Dry	P
15	1	1/3/1998	Saturday	SB entry	Overturned	Careless driving	Night	Dry	P
16	2	2/5/1998	Thursday	SB entry	Overturned	Careless driving	Day	Dry	I
17	3	2/9/1998	Monday	NB entry	Overturned	Careless driving	Day	Dry	I
18	4	3/7/1998	Saturday	SB entry	Overturned	Exceeded safe speed limit	Night	Dry	P
19	5	3/24/1998	Tuesday	SB entry	Overturned	Improper lane change	Day	Dry	I
20	6	5/10/1998	Sunday	NB entry	Hit culvert/ Overturned	Careless driving	Night	Dry	P
21	7	6/30/1998	Tuesday	NB entry	Angle	Careless driving	Night	Dry	P
22	8	8/1/1998	Saturday	SB entry	Collision w/ parked vehicle	Exceeded safe speed limit	Night	Wet	P
23	9	9/4/1998	Friday	SB entry	Overturned	Exceeded safe speed limit	Day	Wet	I
24	10	9/5/1998	Saturday	SB entry	Overturned	Careless driving	Day	Wet	P
25	11	10/24/1998	Saturday	SB entry	Overturned	Exceeded safe speed limit	Day	Wet	I
26	12	11/2/1998	Monday	SB entry	Overturned	Careless driving	Day	Dry	P
27	13	11/30/1998	Monday	SB entry	Overturned	Exceeded safe speed limit	Day	Dry	I
28	1	1/8/1999	Friday	SB entry	Rear End	Improper lane change	Day	Dry	P
29	2	1/19/1999	Tuesday	SB entry	Overturned	Careless driving	Night	Dry	I
30	3	5/16/1999	Sunday	SB entry	Overturned	Careless driving	Night	Dry	P
31	4	6/1/1999	Tuesday	SB entry	Overturned	Exceeded safe speed limit	Night	Dry	I
32	5	8/27/1999	Friday	NB exit	Overturned	Careless driving	Night	Dry	P
33	6	9/8/1999	Wednesday	SB entry	Hit Sign	No Improper action	Day	Wet	I
34	7	10/5/1999	Tuesday	SB entry	Rear End/ Overturned	Careless driving	Day	Wet	I
35	8	10/13/1999	Wednesday	NB entry	Rear End	Careless driving	Night	Dry	I
36	9	10/21/1999	Thursday	SB entry	Overturned	Careless driving	Night	Wet	I
37	10	11/19/1999	Friday	NB entry	Rear End	Followed too close	Day	Wet	P
38	11	11/26/1999	Friday	SB entry	Overturned	Careless driving	Night	Dry	I
39	1	4/26/2000	Wednesday	NB entry	Overturned	Careless driving	Day	Dry	P
40	2	5/2/2000	Tuesday	SB entry	Overturned	Careless driving	Day	Dry	I
41	3	8/14/2000	Monday	SB entry	Sideswipe	Failed to yield R/W	Day	Dry	P
42	4	9/7/2000	Thursday	NB entry	Angle	Failed to yield R/W	Day	Dry	P
43	5	9/20/2000	Wednesday	NB entry	Angle	Failed to yield R/W	Day	Dry	F
44	6	9/23/2000	Saturday	NB entry	Overturned	Careless driving	Night	Dry	P
45	7	11/18/2000	Saturday	SB entry	Overturned	Exceeded safe speed limit	Night	Dry	I
46	8	12/4/2000	Monday	SB exit	Overturned	Careless driving	Day	Dry	I
47	1	3/1/2001	Thursday	SB entry	Overturned	Careless driving	Night	Dry	I
48	2	4/14/2001	Saturday	SB exit	Rear End	Hit and Run	Night	Dry	P
49	3	4/17/2001	Tuesday	SB exit	Hit Sign	DUI	Night	Dry	P
50	4	6/22/2001	Friday	NB exit	Sideswipe	Other(polk)	Day	Wet	P
51	5	10/21/2001	Sunday	SB entry	Overturned	Careless driving	Night	Wet	P
52	6	11/21/2001	Wednesday	SB exit	Overturned	Careless driving	Night	Dry	I
53	1	1/4/2002	Friday	SB Exit	Rear End	Careless driving	Night	Dry	P
54	2	1/4/2002	Friday	NB exit	Parked	No Improper action	Night	Dry	P
55	3	1/8/2002	Tuesday	SB Exit	Overturned	Exceeded safe speed limit	Day	Dry	I
56	4	2/1/2002	Friday	SB Exit	Overturned	Careless driving	Night	Dry	I
57	5	3/12/2002	Tuesday	NB exit	Sideswipe	No Improper action	Night	Dry	I
58	6	3/21/2002	Thursday	NB entry	Rear End	Careless driving	Day	Dry	I
59	7	5/14/2002	Tuesday	SB Exit	Overturned	Careless driving	Night	Wet	P
60	8	6/23/2002	Sunday	SB Entry	Overturned	Careless driving	Day	Wet	I
61	9	6/27/2002	Thursday	SB Exit	Overturned	Careless driving	Day	Dry	I
62	10	6/30/2002	Sunday	SB Exit	Overturned	Exceeded safe speed limit	Day	Wet	P
63	11	7/7/2002	Sunday	SB Entry	Overturned	Careless driving	Day	Wet	P
64	12	9/21/2002	Saturday	SB Entry	Overturned	Careless driving	Day	Dry	I
65	13	11/19/2002	Tuesday	SB Entry	Hit fixed object/ Sign Post	Careless driving	Night	Dry	P
66	14	12/5/2002	Thursday	NB entry	Rear End	Careless driving	Day	Wet	P

No.	No.	Date	Day	Location	Type	Cause	Day/ Night	Wet/ Dry	Severity
67	1	2/10/2003	Monday	SB Entry	Overturned	No Improper action	Night	Wet	P
68	2	2/19/2003	Wednesday	SB Entry	Rear End	ALL OTHER (EXPLAIN)	DUSK	Dry	P
69	3	2/28/2003	Friday	SB Exit	Overturned	Careless driving	Night	Wet	I
70	4	6/19/2003	Thursday	SB Entry	Overturned	No Improper action	Day	Wet	I
71	5	7/22/2003	Tuesday	NB exit	Sideswipe	No Improper action	Day	Dry	P
72	6	7/27/2003	Sunday	SB Entry	Overturned	Careless driving	Day	Dry	I
73	7	8/9/2003	Saturday	SB Exit	Sideswipe	Careless driving	Day	Wet	P
74	8	11/14/2003	Friday	SB Entry	Rear End	Careless driving	DUSK	Dry	P
75	9	11/15/2003	Saturday	SB Entry	Ditch/ Culvert	Careless driving	Night	Dry	P
76	10	11/27/2003	Thursday	SB Entry	Rear End	Careless driving	Night	Dry	I
77	1	1/11/2004	Sunday	NB exit	Overturned	Exceeded safe speed limit	Day	Dry	P
78	2	1/31/2004	Saturday	SB Entry	Sideswipe	Improper lane change	Night	Wet	P
79	3	2/20/2004	Friday	SB Exit	Overturned	Careless driving	Night	Dry	P
80	4	2/26/2004	Thursday	SB Entry	Jackknifed	Careless driving	Night	Dry	P
81	5	2/26/2004	Thursday	SB Entry	Rear End	Careless driving	Dawn	Dry	P
82	6	4/6/2004	Tuesday	NB exit	Sideswipe	Improper lane change	Day	Dry	P
83	7	6/25/2004	Friday	NB exit	Sideswipe	Improper lane change	Day	Dry	I
84	8	6/29/2004	Tuesday	NB exit	Ditch/ Culvert	No Improper action	Dusk	Wet	P
85	9	7/6/2004	Tuesday	NB entry	Rear End	Followed too close	Day	Dry	P
86	10	7/20/2004	Tuesday	SB Entry	Ditch/ Culvert	No Improper action	Day	Wet	P
87	11	7/27/2004	Tuesday	SB Entry	Sideswipe	Failed to yield R/W	Day	Dry	I
88	12	8/22/2004	Sunday	SB Exit	Ditch/ Culvert	No Improper action	Day	Wet	P
89	13	9/2/2004	Thursday	NB exit	Guardrail	Careless driving	Day	Dry	P
90	14	11/9/2004	Tuesday	NB exit	Cargo Loss	Hit and Run	Day	Wet	P
91	15	12/3/2004	Friday	NB entry	Rear End	DUI	Night	Dry	P
92	16	12/3/2004	Friday	SB Entry	Rear End	Careless driving	Night	Dry	P
93	17	12/10/2004	Friday	SB Entry	Angle	Failed to yield R/W	Night	Dry	I
94	18	12/10/2004	Friday	SB Exit	Overturned	Careless driving	Day	Wet	P
95	19	12/25/2004	Saturday	SB Entry	Ditch/ Culvert	No Improper action	Day	Wet	P

* No Form = no form obtained
* No Info = not sufficient information of form to determine
* SB Exit = SB US 27 exit ramp to US 192
* SB Entry = SB US 27 entry ramp from US 192
* NB Exit = NB US 27 exit ramp to US 192
* NB Entry = NB US 27 entry ramp from US 192
* WB Not @ interchange = crash involving vehicle travelling west but did not occur on bridge or ramps of interchange
* EB Not @ interchange = crash involving vehicle travelling east but did not occur on bridge or ramps of interchange
* NB Not @ interchange = crash involving vehicle travelling north but did not occur on bridge or ramps of interchange
* SB Not @ interchange = crash involving vehicle travelling south but did not occur on bridge or ramps of interchange
* P = Property Damage only; I = Injury; F = Fatal.

APPENDIX B: APPROACH DATA STATISTICAL ANALYSES

BEFORE AND AFTER APPROACH SPEED COMPARISON

No.	DATA SET		BEFORE								AFTER							
			Total	**Mean**	**Variance**	**Coefficient of variation**	**% Obeying Speed Limit (55 mph)**	**% Obeying Speed Limit + 5 Mph**	**% Obeying Speed Limit +10 Mph**	**85th Percentile**	**Total**	**Mean**	**Variance**	**Coefficient of variation**	**% Obeying Speed Limit (55 mph)**	**% Obeying Speed Limit + 5 Mph**	**% Obeying Speed Limit +10 Mph**	**85th Percentile**
1	Entire		38515	54.63	41.29	0.12	55.95	83.74	95.82	61.00	40820	51.05	37.95	0.12	78.22	94.44	98.84	57.00
2	Day Time		25860	55.06	41.41	0.12	52.66	81.86	95.25	61.00	27636	51.50	36.53	0.12	76.26	93.89	98.73	57.00
3	Night Time		12655	53.75	39.90	0.12	62.66	87.59	97.00	60.00	13184	50.11	39.62	0.13	82.33	95.59	99.05	56.00
4	Daily	Monday	5248	54.39	41.77	0.12	57.51	84.47	96.04	61.00	6000	51.50	36.54	0.12	75.78	93.73	98.82	57.00
5		Tuesday	4661	54.58	38.34	0.11	56.68	79.94	96.22	61.00	5754	51.04	39.59	0.12	77.79	93.78	98.77	57.00
6		Wednesday	4691	54.96	43.16	0.12	53.61	81.97	94.97	61.00	5990	51.08	39.20	0.12	77.96	94.21	98.96	57.00
7		Thursday	4081	54.62	41.91	0.12	56.04	83.24	96.13	61.00	6088	51.03	38.27	0.12	78.20	94.58	98.70	57.00
8		Friday	7722	54.63	42.88	0.12	55.84	83.36	95.38	61.00	6106	50.77	36.20	0.12	79.87	95.64	98.90	57.00
9		Saturday	7069	54.88	41.42	0.12	54.63	83.21	95.63	61.00	5924	51.06	38.25	0.12	78.81	94.24	98.70	57.00
10		Sunday	5043	54.31	38.32	0.11	57.76	85.60	96.73	60.00	4958	50.82	37.29	0.12	79.23	94.92	99.03	57.00
11	Time of Day	12 MN to 7 AM	7103	53.69	43.47	0.12	61.79	86.64	96.62	60.00	6827	50.62	44.33	0.13	78.57	93.89	98.56	57.00
12		7 AM to 9 AM	3104	55.09	46.63	0.12	52.32	80.61	94.04	62.00	2993	52.24	43.04	0.13	71.07	91.25	97.76	59.00
13		9 AM to 11 AM	3478	54.10	43.91	0.12	58.77	84.91	95.86	61.00	3580	51.35	34.75	0.11	77.99	94.39	99.11	57.00
14		11 AM to 1 PM	3495	54.39	48.28	0.13	55.51	83.58	95.79	61.00	4048	51.57	37.52	0.12	75.99	93.33	98.52	57.00
15		1 PM to 4 PM	5705	55.38	38.77	0.11	51.06	80.72	94.85	61.00	6588	51.68	37.02	0.12	74.57	93.66	98.79	58.00
16		4 PM to 6 PM	4005	55.78	36.70	0.11	48.51	79.38	95.08	62.00	4205	51.38	33.14	0.11	77.34	94.93	99.02	57.00
17		6 PM to 12 MN	11625	54.55	37.04	0.11	57.60	85.50	96.54	60.00	12579	50.31	35.10	0.12	82.71	96.11	99.23	56.00
18	Weekday Time of Day	12 MN to 7 AM	3254	53.53	45.19	0.13	62.14	86.85	96.59	60.00	4232	50.66	40.91	0.13	78.97	94.09	98.79	57.00
19		7 AM to 9 AM	1501	55.20	48.67	0.13	50.57	79.88	94.27	62.00	1864	52.45	44.17	0.13	70.12	91.04	97.53	59.00
20		9 AM to 11 AM	1547	54.23	43.30	0.12	57.34	84.42	95.73	61.00	2140	51.53	36.97	0.12	75.98	94.02	99.02	57.00
21		11 AM to 1 PM	1496	54.19	49.39	0.13	57.69	83.02	95.19	61.00	2347	51.70	37.70	0.12	74.78	92.67	98.34	58.00
22		1 PM to 4 PM	2543	55.32	39.59	0.11	51.75	80.77	94.89	61.00	3738	51.62	39.57	0.12	74.40	92.96	98.64	58.00
23		4 PM to 6 PM	1949	55.77	36.19	0.11	49.36	78.96	94.97	62.00	2360	51.54	31.73	0.11	76.99	94.70	99.11	57.00
24		6 PM to 12 MN	6390	54.63	36.21	0.11	57.15	85.29	96.64	60.00	7151	50.47	36.40	0.12	81.47	95.72	99.24	56.00
25	Weekend Time of Day	12 MN to 7 AM	2343	54.06	41.42	0.12	60.65	86.34	96.63	60.00	1477	50.49	52.81	0.14	77.18	92.62	98.17	58.00
26		7 AM to 9 AM	932	54.79	43.14	0.12	54.83	82.62	94.31	61.00	653	52.18	42.87	0.13	70.90	90.35	97.70	59.00
27		9 AM to 11 AM	1191	54.05	43.06	0.12	60.20	85.81	96.39	60.00	867	51.04	32.99	0.11	81.08	94.23	99.19	56.00
28		11 AM to 1 PM	1272	54.35	46.54	0.13	55.42	84.98	96.86	60.35	1098	51.41	36.81	0.12	78.14	94.08	98.91	57.00
29		1 PM to 4 PM	2004	55.40	36.75	0.11	50.95	81.29	95.11	61.00	1919	51.88	33.80	0.11	73.84	94.37	99.06	58.00
30		4 PM to 6 PM	1304	55.81	38.13	0.11	47.70	79.98	95.09	62.00	1223	51.70	34.72	0.11	75.39	93.95	98.53	57.00
31		6 PM to 12 MN	3066	54.39	36.42	0.11	57.99	85.81	96.84	60.00	3645	50.02	33.59	0.12	84.88	96.60	99.23	56.00
			Total	**Mean**	**Variance**	**Coefficient of variation**	**Proportion of Total Vehicles**				**Total**	**Mean**	**Variance**	**Coefficient of variation**	**Proportion of Total Vehicles**			
32	Speed Range	1 to 35	130	28.09	77.46	0.31	0.003				382	32.22	19.03	0.14	0.009			
33		36 to 47	4406	44.37	6.60	0.06	0.114				10235	43.88	7.73	0.06	0.251			
34		48 to 59	25939	53.83	10.30	0.06	0.673				27144	52.69	9.95	0.06	0.665			
35		60 to 147	8040	63.28	13.78	0.06	0.209				3059	62.80	11.42	0.05	0.075			

HYPOTHESIS TEST FOR A DIFFERENCE IN MEANS - APPROACH SPEED DATA

To determine if the mean speed decreased after DSM installation.

Ho: $Mean_{(before)} - Mean_{(after)} = 0$ **Ha: $Mean_{(before)} - Mean_{(after)} > 0$**

Reject Ho if t test statistic > Critical statistic; 95% significance level

1. Difference in Means - Entire Approach Data Set

$N_{(Before)}$ =	38,515	$N_{(After)}$ =	40,820
Mean Before =	54.631	Mean After =	51.049
Variance Before =	41.286	Variance After =	37.949
t test Statistic =	80.066	Deg. of Free, υ =	78545
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

2. Difference in Means - Day Time Approach Data Set

$N_{(Before)}$ =	25,860	$N_{(After)}$ =	27,636
Mean Before =	55.060	Mean After =	51.496
Variance Before =	41.406	Variance After =	36.534
t test Statistic =	65.924	Deg. of Free, υ =	52621
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

3. Difference in Means - Night Time Approach Data Set

$N_{(Before)}$ =	12,655	$N_{(After)}$ =	13,184
Mean Before =	53.753	Mean After =	50.11
Variance Before =	39.895	Variance After =	39.62
t test Statistic =	46.416	Deg. of Free, υ =	25786
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

4. Difference in Means - Daily Monday Approach Data Set

$N_{(Before)}$ =	5,248	$N_{(After)}$ =	6,000
Mean Before =	54.385	Mean After =	51.499
Variance Before =	41.775	Variance After =	36.537
t test Statistic =	24.353	Deg. of Free, υ =	10812
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

5. Difference in Means - Daily Tuesday Approach Data Set

$N_{(Before)}$ =	4,661	$N_{(After)}$ =	5,754
Mean Before =	54.577	Mean After =	51.035
Variance Before =	38.335	Variance After =	39.595
t test Statistic =	28.817	Deg. of Free, υ =	10032
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

6. Difference in Means - Daily Wednesday Approach Data Set

$N_{(Before)}$ = 4,691 $N_{(After)}$ = 5,990

Mean Before =	54.958	Mean After =	51.082
Variance Before =	43.159	Variance After =	39.199
t test Statistic =	30.890	Deg. of Free, υ =	9837
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

7. Difference in Means - Daily Thursday Approach Data Set

$N_{(Before)}$ = 4,081 $N_{(After)}$ = 6,088

Mean Before =	54.618	Mean After =	51.035
Variance Before =	41.907	Variance After =	38.270
t test Statistic =	27.852	Deg. of Free, υ =	8475
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

8. Difference in Means - Daily Friday Approach Data Set

$N_{(Before)}$ = 7,722 $N_{(After)}$ = 6,106

Mean Before =	54.626	Mean After =	50.772
Variance Before =	42.883	Variance After =	36.201
t test Statistic =	35.966	Deg. of Free, υ =	13519
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

9. Difference in Means - Daily Saturday Approach Data Set

$N_{(Before)}$ = 7,069 $N_{(After)}$ = 5,924

Mean Before =	54.875	Mean After =	51.060
Variance Before =	41.421	Variance After =	38.250
t test Statistic =	34.373	Deg. of Free, υ =	12751
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

10. Difference in Means - Daily Sunday Approach Data Set

$N_{(Before)}$ = 5,043 $N_{(After)}$ = 4,958

Mean Before =	54.307	Mean After =	50.823
Variance Before =	38.319	Variance After =	37.287
t test Statistic =	28.330	Deg. of Free, υ =	9999
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

11. Difference in Means - TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	7,103	$N_{(After)}$ =	6,827
Mean Before =	53.690	Mean After =	50.617
Variance Before =	43.465	Variance After =	44.326
t test Statistic =	27.357	Deg. of Free, ʋ =	13894
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

12. Difference in Means - TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	3,104	$N_{(After)}$ =	2,993
Mean Before =	55.089	Mean After =	52.236
Variance Before =	46.629	Variance After =	43.042
t test Statistic =	16.640	Deg. of Free, ʋ =	6095
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

13. Difference in Means - TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	3,478	$N_{(After)}$ =	3,580
Mean Before =	54.096	Mean After =	51.354
Variance Before =	43.910	Variance After =	34.745
t test Statistic =	18.346	Deg. of Free, ʋ =	6910
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

14. Difference in Means - TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	3,495	$N_{(After)}$ =	4,048
Mean Before =	54.386	Mean After =	51.565
Variance Before =	48.281	Variance After =	37.516
t test Statistic =	18.566	Deg. of Free, ʋ =	7025
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

15. Difference in Means - TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	5,705	$N_{(After)}$ =	6,588
Mean Before =	55.380	Mean After =	51.676
Variance Before =	38.772	Variance After =	37.021
t test Statistic =	33.243	Deg. of Free, ʋ =	11957
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

16. Difference in Means - TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 4,005		$N_{(After)}$ = 4,205	
Mean Before =	55.778	Mean After =	51.383
Variance Before =	36.698	Variance After =	33.137
t test Statistic =	33.666	Deg. of Free, υ =	8127
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

17. Difference in Means - TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 11,625		$N_{(After)}$ = 12,579	
Mean Before =	54.554	Mean After =	50.307
Variance Before =	37.039	Variance After =	35.097
t test Statistic =	54.941	Deg. of Free, υ =	23934
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

18. Difference in Means - Weekday TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 3,254		$N_{(After)}$ = 4,232	
Mean Before =	53.530	Mean After =	50.659
Variance Before =	45.189	Variance After =	40.915
t test Statistic =	18.706	Deg. of Free, υ =	6818
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

19. Difference in Means - Weekday TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 1,501		$N_{(After)}$ = 1,864	
Mean Before =	55.201	Mean After =	52.454
Variance Before =	48.666	Variance After =	44.167
t test Statistic =	11.595	Deg. of Free, υ =	3142
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

20. Difference in Means - Weekday TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 1,547		$N_{(After)}$ = 2,140	
Mean Before =	54.230	Mean After =	51.535
Variance Before =	43.299	Variance After =	36.974
t test Statistic =	12.669	Deg. of Free, υ =	3171
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

21. Difference in Means - Weekday TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,496		$N_{(After)}$ = 2,347	
Mean Before =	54.190	Mean After =	51.699
Variance Before =	49.394	Variance After =	37.702
t test Statistic =	11.244	Deg. of Free, υ =	2871
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

22. Difference in Means - Weekday TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	2,543	$N_{(After)}$ =	3,738
Mean Before =	55.319	Mean After =	51.623
Variance Before =	39.595	Variance After =	39.569
t test Statistic =	22.852	Deg. of Free, υ =	5457
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

23. Difference in Means - Weekday TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,949	$N_{(After)}$ =	2,360
Mean Before =	55.774	Mean After =	51.544
Variance Before =	36.187	Variance After =	31.725
t test Statistic =	23.644	Deg. of Free, υ =	4041
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

24. Difference in Means - Weekday TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	6,390	$N_{(After)}$ =	7,151
Mean Before =	54.627	Mean After =	50.473
Variance Before =	36.212	Variance After =	36.403
t test Statistic =	40.056	Deg. of Free, υ =	13377
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

25. Difference in Means - Weekend TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	2,343	$N_{(After)}$ =	1,477
Mean Before =	54.063	Mean After =	50.494
Variance Before =	41.424	Variance After =	52.807
t test Statistic =	15.441	Deg. of Free, υ =	2856
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

26. Difference in Means - Weekend TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	932	$N_{(After)}$ =	653
Mean Before =	54.789	Mean After =	52.176
Variance Before =	43.144	Variance After =	42.872
t test Statistic =	7.808	Deg. of Free, υ =	1406
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

27. Difference in Means - Weekend TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	1,191	$N_{(After)}$ =	867
Mean Before =	54.047	Mean After =	51.036
Variance Before =	43.058	Variance After =	32.986
t test Statistic =	11.055	Deg. of Free, υ =	1988
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

28. Difference in Means - Weekend TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,272 | $N_{(After)}$ = 1,098

Mean Before = 54.348 | Mean After = 51.413

Variance Before = 46.536 | Variance After = 36.811

t test Statistic = 11.087 | Deg. of Free, υ = 2366

Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

29. Difference in Means - Weeend TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,004 | $N_{(After)}$ = 1,919

Mean Before = 55.398 | Mean After = 51.880

Variance Before = 36.750 | Variance After = 33.801

t test Statistic = 18.554 | Deg. of Free, υ = 3921

Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

30. Difference in Means - Weekend TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 1,304 | $N_{(After)}$ = 1,223

Mean Before = 55.806 | Mean After = 51.700

Variance Before = 38.126 | Variance After = 34.719

t test Statistic = 17.105 | Deg. of Free, υ = 2524

Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

31. Difference in Means - Weekend TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 3,066 | $N_{(After)}$ = 3,645

Mean Before = 54.389 | Mean After = 50.021

Variance Before = 36.416 | Variance After = 33.593

t test Statistic = 30.077 | Deg. of Free, υ = 6417

Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN VARIANCE - APPROACH SPEED DATA

To determine if the speed variance decreased after DSM installation.

Ho: $Variance_{(before)} - Variance_{(after)} = 0$ Ha: $Variance_{(before)} - Variance_{(after)} > 0$

Reject Ho if Fstatistic > Critical statistic; 95% significance level

1. Difference in Variance - Entire Approach Data Set

$N_{(Before)}$ =	38,515	$N_{(After)}$ =	40,820
Variance Before =	41.286	Variance After =	37.949
F Statistic =	1.088	Deg. of Free 1, υ_1 =	38514
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	40819

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

2. Difference in Variance - Day Time Approach Data Set

$N_{(Before)}$ =	25,860	$N_{(After)}$ =	27,636
Variance Before =	41.406	Variance After =	36.534
F Statistic =	1.133	Deg. of Free 1, υ_1 =	25859
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	27635

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

3. Difference in Variance - Night Time Approach Data Set

$N_{(Before)}$ =	12,655	$N_{(After)}$ =	13,184
Variance Before =	39.895	Variance After =	39.618
F Statistic =	1.007	Deg. of Free 1, υ_1 =	12654
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	13183

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

4. Difference in Variance - Daily Monday Approach Data Set

$N_{(Before)}$ =	5,248	$N_{(After)}$ =	6,000
Variance Before =	41.775	Variance After =	36.537
F Statistic =	1.143	Deg. of Free 1, υ_1 =	5247
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	5999

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

5. Difference in Variance - Daily Tuesday Approach Data Set

$N_{(Before)}$ =	4,661	$N_{(After)}$ =	5,754
Variance Before =	38.335	Variance After =	39.595
F Statistic =	0.968	Deg. of Free 1, υ_1 =	4660
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	5753

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

6. Difference in Variance - Daily Wednesday Approach Data Set

$N_{(Before)}$ = 4,691 $N_{(After)}$ = 5,990

Variance Before = 43.159 Variance After = 39.199

F Statistic = 1.101 Deg. of Free 1, υ_1 = 4690

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 5989

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

7. Difference in Variance - Daily Thursday Approach Data Set

$N_{(Before)}$ = 4,081 $N_{(After)}$ = 6,088

Variance Before = 41.907 Variance After = 38.270

F Statistic = 1.095 Deg. of Free 1, υ_1 = 4080

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 6087

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

8. Difference in Variance - Daily Friday Approach Data Set

$N_{(Before)}$ = 7,722 $N_{(After)}$ = 6,106

Variance Before = 42.883 Variance After = 36.201

F Statistic = 1.185 Deg. of Free 1, υ_1 = 7721

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 6105

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

9. Difference in Variance - Daily Saturday Approach Data Set

$N_{(Before)}$ = 7,069 $N_{(After)}$ = 5,924

Variance Before = 41.421 Variance After = 38.250

F Statistic = 1.083 Deg. of Free 1, υ_1 = 7068

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 5923

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

10. Difference in Variance - Daily Sunday Approach Data Set

$N_{(Before)}$ = 5,043 $N_{(After)}$ = 4,958

Variance Before = 38.319 Variance After = 37.287

F Statistic = 1.028 Deg. of Free 1, υ_1 = 5042

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 4957

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

11. Difference in Variance - TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 7,103 $N_{(After)}$ = 6,827

Variance Before = 43.465 Variance After = 44.326

F Statistic = 0.981 Deg. of Free 1, υ_1 = 7102

Critical Statistic = 1.00 Deg. of Free 2, υ_2 = 6826

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

12. Difference in Variance - TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 3,104 | $N_{(After)}$ = 2,993

Variance Before = 46.629 | Variance After = 43.042

F Statistic = 1.083 | Deg. of Free 1, υ_1 = 3103

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 2992

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

13. Difference in Variance - TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 3,478 | $N_{(After)}$ = 3,580

Variance Before = 43.910 | Variance After = 34.745

F Statistic = 1.264 | Deg. of Free 1, υ_1 = 3477

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 3579

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

14. Difference in Variance - TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 3,495 | $N_{(After)}$ = 4,048

Variance Before = 48.281 | Variance After = 37.516

F Statistic = 1.287 | Deg. of Free 1, υ_1 = 3494

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 4047

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

15. Difference in Variance - TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 5,705 | $N_{(After)}$ = 6,588

Variance Before = 38.772 | Variance After = 37.021

F Statistic = 1.047 | Deg. of Free 1, υ_1 = 5704

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 6587

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

16. Difference in Variance - TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 4,005 | $N_{(After)}$ = 4,205

Variance Before = 36.698 | Variance After = 33.137

F Statistic = 1.107 | Deg. of Free 1, υ_1 = 4004

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 4204

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

17. Difference in Variance - TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 11,625 | $N_{(After)}$ = 12,579

Variance Before = 37.039 | Variance After = 35.097

F Statistic = 1.055 | Deg. of Free 1, υ_1 = 11624

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 12578

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

18. Difference in Variance - Weekday TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 3,254	$N_{(After)}$ = 4,232
Variance Before = 45.189	Variance After = 40.915
F Statistic = 1.104	Deg. of Free 1, υ_1 = 3253
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 4231

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

19. Difference in Variance - Weekday TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 1,501	$N_{(After)}$ = 1,864
Variance Before = 48.666	Variance After = 44.167
F Statistic = 1.102	Deg. of Free 1, υ_1 = 1500
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 1863

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

20. Difference in Variance - Weekday TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 1,547	$N_{(After)}$ = 2,140
Variance Before = 43.299	Variance After = 36.974
F Statistic = 1.171	Deg. of Free 1, υ_1 = 1546
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 2139

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

21. Difference in Variance - Weekday TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,496	$N_{(After)}$ = 2,347
Variance Before = 49.394	Variance After = 37.702
F Statistic = 1.310	Deg. of Free 1, υ_1 = 1495
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 2346

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

22. Difference in Variance - Weekday TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,543	$N_{(After)}$ = 3,738
Variance Before = 39.595	Variance After = 39.569
F Statistic = 1.001	Deg. of Free 1, υ_1 = 2542
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 3737

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

23. Difference in Variance - Weekday TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 1,949	$N_{(After)}$ = 2,360
Variance Before = 36.187	Variance After = 31.725
F Statistic = 1.141	Deg. of Free 1, υ_1 = 1948
Critical Statistic = 1.00	Deg. of Free 2, υ_2 = 2359

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

24. Difference in Variance - Weekday TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	6,390	$N_{(After)}$ =	7,151
Variance Before =	36.212	Variance After =	36.403
F Statistic =	0.995	Deg. of Free 1, υ_1 =	6389
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	7150

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

25. Difference in Variance - Weekend TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	2,343	$N_{(After)}$ =	1,477
Variance Before =	41.424	Variance After =	52.807
F Statistic =	0.784	Deg. of Free 1, υ_1 =	2342
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	1476

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

26. Difference in Variance - Weekend TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	932	$N_{(After)}$ =	653
Variance Before =	43.144	Variance After =	42.872
F Statistic =	1.006	Deg. of Free 1, υ_1 =	931
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	652

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

27. Difference in Variance - Weekend TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	1,191	$N_{(After)}$ =	867
Variance Before =	43.058	Variance After =	32.986
F Statistic =	1.305	Deg. of Free 1, υ_1 =	1190
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	866

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

28. Difference in Variance - Weekend TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	1,272	$N_{(After)}$ =	1,098
Variance Before =	46.536	Variance After =	36.811
F Statistic =	1.264	Deg. of Free 1, υ_1 =	1271
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	1097

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

29. Difference in Variance - Weeend TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,004 | $N_{(After)}$ = 1,919

Variance Before = 36.750 | Variance After = 33.801

F Statistic = 1.087 | Deg. of Free 1, υ_1 = 2003

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 1918

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

30. Difference in Variance - Weekend TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 1,304 | $N_{(After)}$ = 1,223

Variance Before = 38.126 | Variance After = 34.719

F Statistic = 1.098 | Deg. of Free 1, υ_1 = 1303

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 1222

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

31. Difference in Variance - Weekend TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 3,066 | $N_{(After)}$ = 3,645

Variance Before = 36.416 | Variance After = 33.593

F Statistic = 1.084 | Deg. of Free 1, υ_1 = 3065

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 3644

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - APPROACH SPEED DATA COMPLIANCE WITH SPEED LIMIT - 55 MPH

To determine if the proportion of drivers complying with the speed limit of 55 mph increased after DSM installation.

Ho: $Proportion_{(before)} - Proportion_{(after)} = 0$ **Ha: $Proportion_{(before)} - Proportion_{(after)} < 0$**

Reject Ho if Z statistic test < Critical statistic; 95% significance level

1. Difference in Proportions - Entire Approach Data Set

$N_{(Before)}$ =	38,515	$N_{(After)}$ =	40,820
Proportion Before =	0.559	Proportion After =	0.782
Z test Statistic =	-66.87	p(pooled) =	0.674
Critical Statistic =	-1.645	q(pooled) =	0.326

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

2. Difference in Proportions - Day Time Approach Data Set

$N_{(Before)}$ =	25,860	$N_{(After)}$ =	27,636
Proportion Before =	0.527	Proportion After =	0.763
Z test Statistic =	-57.11	p(pooled) =	0.649
Critical Statistic =	-1.645	q(pooled) =	0.351

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

3. Difference in Proportions - Night Time Approach Data Set

$N_{(Before)}$ =	12,655	$N_{(After)}$ =	13,184
Proportion Before =	0.627	Proportion After =	0.823
Z test Statistic =	-35.47	p(pooled) =	0.727
Critical Statistic =	-1.645	q(pooled) =	0.273

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

4. Difference in Proportions - Daily Monday Approach Data Set

$N_{(Before)}$ =	5,248	$N_{(After)}$ =	6,000
Proportion Before =	0.575	Proportion After =	0.758
Z test Statistic =	-20.61	p(pooled) =	0.673
Critical Statistic =	-1.645	q(pooled) =	0.327

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday Approach Data Set

$N_{(Before)}$ =	4,661	$N_{(After)}$ =	5,754
Proportion Before =	0.567	Proportion After =	0.778
Z test Statistic =	-23.03	p(pooled) =	0.683
Critical Statistic =	-1.645	q(pooled) =	0.317

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday Approach Data Set

$N_{(Before)}$ =	4,691	$N_{(After)}$ =	5,990
Proportion Before =	0.536	Proportion After =	0.780
Z test Statistic =	-26.62	p(pooled) =	0.673
Critical Statistic =	-1.645	q(pooled) =	0.327

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

7. Difference in Proportions - Daily Thursday Approach Data Set

$N_{(Before)}$ =	4,081	$N_{(After)}$ =	6,088
Proportion Before =	0.560	Proportion After =	0.782
Z test Statistic =	-23.75	p(pooled) =	0.693
Critical Statistic =	-1.645	q(pooled) =	0.307

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

8. Difference in Proportions - Daily Friday Approach Data Set

$N_{(Before)}$ =	7,722	$N_{(After)}$ =	6,106
Proportion Before =	0.558	Proportion After =	0.799
Z test Statistic =	-29.72	p(pooled) =	0.665
Critical Statistic =	-1.645	q(pooled) =	0.335

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

9. Difference in Proportions - Daily Saturday Approach Data Set

$N_{(Before)}$ =	7,069	$N_{(After)}$ =	5,924
Proportion Before =	0.546	Proportion After =	0.788
Z test Statistic =	-28.91	p(pooled) =	0.657
Critical Statistic =	-1.645	q(pooled) =	0.343

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

10. Difference in Proportions - Daily Sunday Approach Data Set

$N_{(Before)}$ =	5,043	$N_{(After)}$ =	4,958
Proportion Before =	0.578	Proportion After =	0.792
Z test Statistic =	-23.08	p(pooled) =	0.684
Critical Statistic =	-1.645	q(pooled) =	0.316

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 7,103 $N_{(After)}$ = 6,827
Proportion Before = 0.618 Proportion After = 0.786

Z test Statistic = -21.61 p(pooled) = 0.700
Critical Statistic = -1.645 q(pooled) = 0.300

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 3,104 $N_{(After)}$ = 2,993
Proportion Before = 0.523 Proportion After = 0.711

Z test Statistic = -15.04 p(pooled) = 0.615
Critical Statistic = -1.645 q(pooled) = 0.385

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

13. Difference in Proportions - TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 3,478 $N_{(After)}$ = 3,580
Proportion Before = 0.588 Proportion After = 0.780

Z test Statistic = -17.38 p(pooled) = 0.685
Critical Statistic = -1.645 q(pooled) = 0.315

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

14. Difference in Proportions - TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 3,495 $N_{(After)}$ = 4,048
Proportion Before = 0.555 Proportion After = 0.760

Z test Statistic = -18.79 p(pooled) = 0.665
Critical Statistic = -1.645 q(pooled) = 0.335

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 5,705 $N_{(After)}$ = 6,588
Proportion Before = 0.511 Proportion After = 0.746

Z test Statistic = -27.03 p(pooled) = 0.637
Critical Statistic = -1.645 q(pooled) = 0.363

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 4,005 $N_{(After)}$ = 4,205
Proportion Before = 0.485 Proportion After = 0.773

Z test Statistic = -27.08 p(pooled) = 0.633
Critical Statistic = -1.645 q(pooled) = 0.367

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	11,625	$N_{(After)}$ =	12,579
Proportion Before =	0.576	Proportion After =	0.827
Z test Statistic =	-42.86	p(pooled) =	0.706
Critical Statistic =	-1.645	q(pooled) =	0.294

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	3,254	$N_{(After)}$ =	4,232
Proportion Before =	0.621	Proportion After =	0.790
Z test Statistic =	-16.02	p(pooled) =	0.717
Critical Statistic =	-1.645	q(pooled) =	0.283

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	1,501	$N_{(After)}$ =	1,864
Proportion Before =	0.506	Proportion After =	0.701
Z test Statistic =	-11.58	p(pooled) =	0.614
Critical Statistic =	-1.645	q(pooled) =	0.386

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	1,547	$N_{(After)}$ =	2,140
Proportion Before =	0.573	Proportion After =	0.760
Z test Statistic =	-11.99	p(pooled) =	0.682
Critical Statistic =	-1.645	q(pooled) =	0.318

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	1,496	$N_{(After)}$ =	2,347
Proportion Before =	0.577	Proportion After =	0.748
Z test Statistic =	-11.08	p(pooled) =	0.681
Critical Statistic =	-1.645	q(pooled) =	0.319

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	2,543	$N_{(After)}$ =	3,738
Proportion Before =	0.517	Proportion After =	0.744
Z test Statistic =	-18.50	p(pooled) =	0.652
Critical Statistic =	-1.645	q(pooled) =	0.348

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,949	$N_{(After)}$ =	2,360
Proportion Before =	0.494	Proportion After =	0.770
Z test Statistic =	-18.87	p(pooled) =	0.645
Critical Statistic =	-1.645	q(pooled) =	0.355

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	6,390	$N_{(After)}$ =	7,151
Proportion Before =	0.572	Proportion After =	0.815
Z test Statistic =	-30.83	p(pooled) =	0.700
Critical Statistic =	-1.645	q(pooled) =	0.300

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	2,343	$N_{(After)}$ =	1,477
Proportion Before =	0.606	Proportion After =	0.772
Z test Statistic =	-10.59	p(pooled) =	0.670
Critical Statistic =	-1.645	q(pooled) =	0.330

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	932	$N_{(After)}$ =	653
Proportion Before =	0.548	Proportion After =	0.709
Z test Statistic =	-6.47	p(pooled) =	0.615
Critical Statistic =	-1.645	q(pooled) =	0.385

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	1,191	$N_{(After)}$ =	867
Proportion Before =	0.602	Proportion After =	0.811
Z test Statistic =	-10.11	p(pooled) =	0.690
Critical Statistic =	-1.645	q(pooled) =	0.310

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	1,272	$N_{(After)}$ =	1,098
Proportion Before =	0.554	Proportion After =	0.781
Z test Statistic =	-11.64	p(pooled) =	0.659
Critical Statistic =	-1.645	q(pooled) =	0.341

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	2,004	$N_{(After)}$ =	1,919
Proportion Before =	0.509	Proportion After =	0.738
Z test Statistic =	-14.78	p(pooled) =	0.621
Critical Statistic =	-1.645	q(pooled) =	0.379

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,304	$N_{(After)}$ =	1,223
Proportion Before =	0.477	Proportion After =	0.754
Z test Statistic =	-14.27	p(pooled) =	0.611
Critical Statistic =	-1.645	q(pooled) =	0.389

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	3,066	$N_{(After)}$ =	3,645
Proportion Before =	0.580	Proportion After =	0.849
Z test Statistic =	-24.60	p(pooled) =	0.726
Critical Statistic =	-1.645	q(pooled) =	0.274

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - APPROACH SPEED DATA
COMPLIANCE WITH SPEED LIMIT + 5 MPH

To determine if the proportion of drivers complying with the speed limit of 55 mph + 5 mph increased after DSM installation.

Ho: $Proportion_{(before)}$ - $Proportion_{(after)}$ = 0 **Ha: $Proportion_{(before)}$ - $Proportion_{(after)}$ < 0**

Reject Ho if Z test statistic < Critical statistic; 95% significance level

1. Difference in Proportions - Entire Approach Data Set

$N_{(Before)}$ =	38,515	$N_{(After)}$ =	40,820
Proportion Before =	0.837	Proportion After =	0.944
Z test Statistic =	-48.61	p(pooled) =	0.892
Critical Statistic =	-1.645	q(pooled) =	0.108

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

2. Difference in Proportions - Day Time Approach Data Set

$N_{(Before)}$ =	25,860	$N_{(After)}$ =	27,636
Proportion Before =	0.819	Proportion After =	0.939
Z test Statistic =	-42.91	p(pooled) =	0.881
Critical Statistic =	-1.645	q(pooled) =	0.119

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

3. Difference in Proportions - Night Time Approach Data Set

$N_{(Before)}$ =	12,655	$N_{(After)}$ =	13,184
Proportion Before =	0.876	Proportion After =	0.956
Z test Statistic =	-23.27	p(pooled) =	0.917
Critical Statistic =	-1.645	q(pooled) =	0.083

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

4. Difference in Proportions - Daily Monday Approach Data Set

$N_{(Before)}$ =	5,248	$N_{(After)}$ =	6,000
Proportion Before =	0.845	Proportion After =	0.937
Z test Statistic =	-15.93	p(pooled) =	0.894
Critical Statistic =	-1.645	q(pooled) =	0.106

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday Approach Data Set

$N_{(Before)}$ =	4,661	$N_{(After)}$ =	5,754
Proportion Before =	0.799	Proportion After =	0.938
Z test Statistic =	-21.30	p(pooled) =	0.876
Critical Statistic =	-1.645	q(pooled) =	0.124

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday Approach Data Set

$N_{(Before)}$ =	4,691		$N_{(After)}$ =	5,990	
Proportion Before =	0.820		Proportion After =		0.942
Z test Statistic =	-19.93		p(pooled) =	0.888	
Critical Statistic =	-1.645		q(pooled) =	0.112	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

7. Difference in Proportions - Daily Thursday Approach Data Set

$N_{(Before)}$ =	4,081		$N_{(After)}$ =	6,088	
Proportion Before =	0.832		Proportion After =		0.946
Z test Statistic =	-18.71		p(pooled) =	0.900	
Critical Statistic =	-1.645		q(pooled) =	0.100	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

8. Difference in Proportions - Daily Friday Approach Data Set

$N_{(Before)}$ =	7,722		$N_{(After)}$ =	6,106	
Proportion Before =	0.834		Proportion After =		0.956
Z test Statistic =	-22.73		p(pooled) =	0.888	
Critical Statistic =	-1.645		q(pooled) =	0.112	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

9. Difference in Proportions - Daily Saturday Approach Data Set

$N_{(Before)}$ =	7,069		$N_{(After)}$ =	5,924	
Proportion Before =	0.832		Proportion After =		0.942
Z test Statistic =	-19.45		p(pooled) =	0.882	
Critical Statistic =	-1.645		q(pooled) =	0.118	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

10. Difference in Proportions - Daily Sunday Approach Data Set

$N_{(Before)}$ =	5,043		$N_{(After)}$ =	4,958	
Proportion Before =	0.856		Proportion After =		0.949
Z test Statistic =	-15.68		p(pooled) =	0.902	
Critical Statistic =	-1.645		q(pooled) =	0.098	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	7,103		$N_{(After)}$ =	6,827	
Proportion Before =	0.866		Proportion After =		0.939
Z test Statistic =	-14.39		p(pooled) =	0.902	
Critical Statistic =	-1.645		q(pooled) =	0.098	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	3,104		$N_{(After)}$ =	2,993	
Proportion Before =	0.806		Proportion After =		0.912
Z test Statistic =	-11.91		p(pooled) =	0.858	
Critical Statistic =	-1.645		q(pooled) =	0.142	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

13. Difference in Proportions - TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	3,478		$N_{(After)}$ =	3,580	
Proportion Before =	0.849		Proportion After =		0.944
Z test Statistic =	-13.11		p(pooled) =	0.897	
Critical Statistic =	-1.645		q(pooled) =	0.103	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

14. Difference in Proportions - TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	3,495		$N_{(After)}$ =	4,048	
Proportion Before =	0.836		Proportion After =		0.933
Z test Statistic =	-13.40		p(pooled) =	0.888	
Critical Statistic =	-1.645		q(pooled) =	0.112	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	5,705		$N_{(After)}$ =	6,588	
Proportion Before =	0.807		Proportion After =		0.937
Z test Statistic =	-21.74		p(pooled) =	0.877	
Critical Statistic =	-1.645		q(pooled) =	0.123	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	4,005		$N_{(After)}$ =	4,205	
Proportion Before =	0.794		Proportion After =		0.949
Z test Statistic =	-21.20		p(pooled) =	0.873	
Critical Statistic =	-1.645		q(pooled) =	0.127	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	11,625		$N_{(After)}$ =	12,579	
Proportion Before =	0.855		Proportion After =		0.961
Z test Statistic =	-28.85		p(pooled) =	0.910	
Critical Statistic =	-1.645		q(pooled) =	0.090	

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 3,254 | $N_{(After)}$ = 4,232
Proportion Before = 0.868 | Proportion After = 0.941

Z test Statistic = -10.83 | p(pooled) = 0.909
Critical Statistic = -1.645 | q(pooled) = 0.091

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 1,501 | $N_{(After)}$ = 1,864
Proportion Before = 0.799 | Proportion After = 0.910

Z test Statistic = -9.29 | p(pooled) = 0.861
Critical Statistic = -1.645 | q(pooled) = 0.139

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 1,547 | $N_{(After)}$ = 2,140
Proportion Before = 0.844 | Proportion After = 0.940

Z test Statistic = -9.58 | p(pooled) = 0.900
Critical Statistic = -1.645 | q(pooled) = 0.100

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,496 | $N_{(After)}$ = 2,347
Proportion Before = 0.830 | Proportion After = 0.927

Z test Statistic = -9.29 | p(pooled) = 0.889
Critical Statistic = -1.645 | q(pooled) = 0.111

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,543 | $N_{(After)}$ = 3,738
Proportion Before = 0.808 | Proportion After = 0.930

Z test Statistic = -14.61 | p(pooled) = 0.880
Critical Statistic = -1.645 | q(pooled) = 0.120

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ = 1,949 | $N_{(After)}$ = 2,360
Proportion Before = 0.790 | Proportion After = 0.947

Z test Statistic = -15.59 | p(pooled) = 0.876
Critical Statistic = -1.645 | q(pooled) = 0.124

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 6,390 $N_{(After)}$ = 7,151
Proportion Before = 0.853 Proportion After = 0.957

Z test Statistic = -20.96 p(pooled) = 0.908
Critical Statistic = -1.645 q(pooled) = 0.092

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 2,343 $N_{(After)}$ = 1,477
Proportion Before = 0.863 Proportion After = 0.926

Z test Statistic = -5.98 p(pooled) = 0.888
Critical Statistic = -1.645 q(pooled) = 0.112

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 932 $N_{(After)}$ = 653
Proportion Before = 0.826 Proportion After = 0.904

Z test Statistic = -4.34 p(pooled) = 0.858
Critical Statistic = -1.645 q(pooled) = 0.142

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 1,191 $N_{(After)}$ = 867
Proportion Before = 0.858 Proportion After = 0.942

Z test Statistic = -6.12 p(pooled) = 0.894
Critical Statistic = -1.645 q(pooled) = 0.106

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,272 $N_{(After)}$ = 1,098
Proportion Before = 0.850 Proportion After = 0.941

Z test Statistic = -7.11 p(pooled) = 0.892
Critical Statistic = -1.645 q(pooled) = 0.108

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,004 $N_{(After)}$ = 1,919
Proportion Before = 0.813 Proportion After = 0.944

Z test Statistic = -12.47 p(pooled) = 0.877
Critical Statistic = -1.645 q(pooled) = 0.123

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,304	$N_{(After)}$ =	1,223
Proportion Before =	0.800	Proportion After =	0.939
Z test Statistic =	-10.35	p(pooled) =	0.867
Critical Statistic =	-1.645	q(pooled) =	0.133

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	3,066	$N_{(After)}$ =	3,645
Proportion Before =	0.858	Proportion After =	0.966
Z test Statistic =	-15.93	p(pooled) =	0.917
Critical Statistic =	-1.645	q(pooled) =	0.083

Hence: Reject Ho - Conclude 55 + 5 mph Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - APPROACH SPEED DATA
COMPLIANCE WITH SPEED LIMIT + 10 MPH

To determine if the proportion of drivers complying with the speed limit of 55 mph + 10 mph increased after DSM installation.

Ho: $Proportion_{(before)} - Proportion_{(after)} = 0$ **Ha: $Proportion_{(before)} - Proportion_{(after)} < 0$**

Reject Ho if Z test statistic < Critical statistic; 95% significance level

1. Difference in Proportions - Entire Approach Data Set

$N_{(Before)}$ =	38,515	$N_{(After)}$ =	40,820
Proportion Before =	0.958	Proportion After =	0.988
Z test Statistic =	-26.53	p(pooled) =	0.974
Critical Statistic =	-1.645	q(pooled) =	0.026

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

2. Difference in Proportions - Day Time Approach Data Set

$N_{(Before)}$ =	25,860	$N_{(After)}$ =	27,636
Proportion Before =	0.952	Proportion After =	0.987
Z test Statistic =	-23.81	p(pooled) =	0.970
Critical Statistic =	-1.645	q(pooled) =	0.030

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

3. Difference in Proportions - Night Time Approach Data Set

$N_{(Before)}$ =	12,655	$N_{(After)}$ =	13,184
Proportion Before =	0.970	Proportion After =	0.991
Z test Statistic =	-11.93	p(pooled) =	0.980
Critical Statistic =	-1.645	q(pooled) =	0.020

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

4. Difference in Proportions - Daily Monday Approach Data Set

$N_{(Before)}$ =	5,248	$N_{(After)}$ =	6,000
Proportion Before =	0.960	Proportion After =	0.988
Z test Statistic =	-9.46	p(pooled) =	0.975
Critical Statistic =	-1.645	q(pooled) =	0.025

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday Approach Data Set

$N_{(Before)}$ =	4,661	$N_{(After)}$ =	5,754
Proportion Before =	0.962	Proportion After =	0.988
Z test Statistic =	-8.48	p(pooled) =	0.976
Critical Statistic =	-1.645	q(pooled) =	0.024

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday Approach Data Set

$N_{(Before)}$ =	4,691	$N_{(After)}$ =	5,990
Proportion Before =	0.950	Proportion After =	0.990
Z test Statistic =	-12.44	p(pooled) =	0.972
Critical Statistic =	-1.645	q(pooled) =	0.028

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

7. Difference in Proportions - Daily Thursday Approach Data Set

$N_{(Before)}$ =	4,081	$N_{(After)}$ =	6,088
Proportion Before =	0.961	Proportion After =	0.987
Z test Statistic =	-8.43	p(pooled) =	0.977
Critical Statistic =	-1.645	q(pooled) =	0.023

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

8. Difference in Proportions - Daily Friday Approach Data Set

$N_{(Before)}$ =	7,722	$N_{(After)}$ =	6,106
Proportion Before =	0.954	Proportion After =	0.989
Z test Statistic =	-11.94	p(pooled) =	0.969
Critical Statistic =	-1.645	q(pooled) =	0.031

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

9. Difference in Proportions - Daily Saturday Approach Data Set

$N_{(Before)}$ =	7,069	$N_{(After)}$ =	5,924
Proportion Before =	0.956	Proportion After =	0.987
Z test Statistic =	-10.27	p(pooled) =	0.970
Critical Statistic =	-1.645	q(pooled) =	0.030

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

10. Difference in Proportions - Daily Sunday Approach Data Set

$N_{(Before)}$ =	5,043	$N_{(After)}$ =	4,958
Proportion Before =	0.967	Proportion After =	0.990
Z test Statistic =	-7.98	p(pooled) =	0.979
Critical Statistic =	-1.645	q(pooled) =	0.021

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	7,103	$N_{(After)}$ =	6,827
Proportion Before =	0.966	Proportion After =	0.986
Z test Statistic =	-7.45	p(pooled) =	0.976
Critical Statistic =	-1.645	q(pooled) =	0.024

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	3,104	$N_{(After)}$ =	2,993
Proportion Before =	0.940	Proportion After =	0.978
Z test Statistic =	-7.30	p(pooled) =	0.959
Critical Statistic =	-1.645	q(pooled) =	0.041

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

13. Difference in Proportions - TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	3,478	$N_{(After)}$ =	3,580
Proportion Before =	0.959	Proportion After =	0.991
Z test Statistic =	-8.74	p(pooled) =	0.975
Critical Statistic =	-1.645	q(pooled) =	0.025

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

14. Difference in Proportions - TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	3,495	$N_{(After)}$ =	4,048
Proportion Before =	0.958	Proportion After =	0.985
Z test Statistic =	-7.22	p(pooled) =	0.973
Critical Statistic =	-1.645	q(pooled) =	0.027

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	5,705	$N_{(After)}$ =	6,588
Proportion Before =	0.948	Proportion After =	0.988
Z test Statistic =	-12.68	p(pooled) =	0.970
Critical Statistic =	-1.645	q(pooled) =	0.030

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	4,005	$N_{(After)}$ =	4,205
Proportion Before =	0.951	Proportion After =	0.990
Z test Statistic =	-10.65	p(pooled) =	0.971
Critical Statistic =	-1.645	q(pooled) =	0.029

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	11,625	$N_{(After)}$ =	12,579
Proportion Before =	0.965	Proportion After =	0.992
Z test Statistic =	-14.70	p(pooled) =	0.979
Critical Statistic =	-1.645	q(pooled) =	0.021

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ =	3,254	$N_{(After)}$ =		4,232
Proportion Before =	0.966	Proportion After	=	0.988
Z test Statistic =	-6.50	p(pooled)	=	0.978
Critical Statistic =	-1.645	q(pooled)	=	0.022

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ =	1,501	$N_{(After)}$ =		1,864
Proportion Before =	0.943	Proportion After	=	0.975
Z test Statistic =	-4.84	p(pooled)	=	0.961
Critical Statistic =	-1.645	q(pooled)	=	0.039

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ =	1,547	$N_{(After)}$ =		2,140
Proportion Before =	0.957	Proportion After	=	0.990
Z test Statistic =	-6.49	p(pooled)	=	0.976
Critical Statistic =	-1.645	q(pooled)	=	0.024

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ =	1,496	$N_{(After)}$ =		2,347
Proportion Before =	0.952	Proportion After	=	0.983
Z test Statistic =	-5.69	p(pooled)	=	0.971
Critical Statistic =	-1.645	q(pooled)	=	0.029

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ =	2,543	$N_{(After)}$ =		3,738
Proportion Before =	0.949	Proportion After	=	0.986
Z test Statistic =	-8.72	p(pooled)	=	0.971
Critical Statistic =	-1.645	q(pooled)	=	0.029

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,949	$N_{(After)}$ =		2,360
Proportion Before =	0.950	Proportion After	=	0.991
Z test Statistic =	-8.25	p(pooled)	=	0.972
Critical Statistic =	-1.645	q(pooled)	=	0.028

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ = 6,390 | $N_{(After)}$ = 7,151
Proportion Before = 0.966 | Proportion After = 0.992

Z test Statistic = -10.86 | p(pooled) = 0.980
Critical Statistic = -1.645 | q(pooled) = 0.020

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM Approach Data Set

$N_{(Before)}$ = 2,343 | $N_{(After)}$ = 1,477
Proportion Before = 0.966 | Proportion After = 0.982

Z test Statistic = -2.83 | p(pooled) = 0.972
Critical Statistic = -1.645 | q(pooled) = 0.028

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM Approach Data Set

$N_{(Before)}$ = 932 | $N_{(After)}$ = 653
Proportion Before = 0.943 | Proportion After = 0.977

Z test Statistic = -3.28 | p(pooled) = 0.957
Critical Statistic = -1.645 | q(pooled) = 0.043

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM Approach Data Set

$N_{(Before)}$ = 1,191 | $N_{(After)}$ = 867
Proportion Before = 0.964 | Proportion After = 0.992

Z test Statistic = -4.08 | p(pooled) = 0.976
Critical Statistic = -1.645 | q(pooled) = 0.024

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM Approach Data Set

$N_{(Before)}$ = 1,272 | $N_{(After)}$ = 1,098
Proportion Before = 0.969 | Proportion After = 0.989

Z test Statistic = -3.40 | p(pooled) = 0.978
Critical Statistic = -1.645 | q(pooled) = 0.022

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM Approach Data Set

$N_{(Before)}$ = 2,004 | $N_{(After)}$ = 1,919
Proportion Before = 0.951 | Proportion After = 0.991

Z test Statistic = -7.30 | p(pooled) = 0.970
Critical Statistic = -1.645 | q(pooled) = 0.030

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM Approach Data Set

$N_{(Before)}$ =	1,304	$N_{(After)}$ =	1,223
Proportion Before =	0.951	Proportion After =	0.985
Z test Statistic =	-4.87	p(pooled) =	0.968
Critical Statistic =	-1.645	q(pooled) =	0.032

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN Approach Data Set

$N_{(Before)}$ =	3,066	$N_{(After)}$ =	3,645
Proportion Before =	0.968	Proportion After =	0.992
Z test Statistic =	-7.23	p(pooled) =	0.981
Critical Statistic =	-1.645	q(pooled) =	0.019

Hence: Reject Ho - Conclude 55 + 10 mph Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN MEANS - APPROACH SPEED DATA
SPEED RANGES

To determine if the mean speed of vehicles traveling in the speed ranges decreased after DSM installation.

Ho: $Mean_{(before)} - Mean_{(after)} = 0$ **Ha: $Mean_{(before)} - Mean_{(after)} > 0$**

Reject Ho if t test statistic > Critical statistic; 95% significance level

1. Difference in Means - 1 to 35 Speed Range Approach Data Set

$N_{(Before)}$ = 130 $N_{(After)}$ = 382
Mean Before = 28.092 Mean After = 32.217
Variance Before = 77.464 Variance After = 19.031

t test Statistic = -5.133 Deg. of Free, υ = 151
Critical Statistic = 1.645

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

2. Difference in Means - 36 to 47 Speed Range Approach Data Set

$N_{(Before)}$ = 4,406 $N_{(After)}$ = 10,235
Mean Before = 44.371 Mean After = 43.879
Variance Before = 6.600 Variance After = 7.730

t test Statistic = 10.374 Deg. of Free, υ = 8984
Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

3. Difference in Means - 48 to 59 Speed Range Approach Data Set

$N_{(Before)}$ = 25,939 $N_{(After)}$ = 27,144
Mean Before = 53.826 Mean After = 52.692
Variance Before = 10.298 Variance After = 9.950

t test Statistic = 41.044 Deg. of Free, υ = 52874
Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

4. Difference in Means - 60 to 147Speed Range Approach Data Set

$N_{(Before)}$ = 8,040 $N_{(After)}$ = 3,059
Mean Before = 63.277 Mean After = 62.804
Variance Before = 13.778 Variance After = 11.417

t test Statistic = 6.404 Deg. of Free, υ = 6028
Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - APPROACH SPEED DATA SPEED RANGES

To determine if the proportion of drivers in the lower speed ranges increased and the proportion of drivers in the upper speed ranges decreased after DSM installation.

Lower Ranges: **Ho: $Proportion_{(before)} - Proportion_{(after)} = 0$** **Ha: $Proportion_{(before)} - Proportion_{(after)} < 0$**

Upper Ranges: **Ho: $Proportion_{(before)} - Proportion_{(after)} = 0$** **Ha: $Proportion_{(before)} - Proportion_{(after)} > 0$**

Reject Ho if Z statistic test < Critical statistic; 95% significance level

1. Difference in Proportions - 1 to 35 Speed Range Approach Data Set

$N_{(Before)}$ =	130	$N_{(After)}$ =	382
Proportion Before =	0.003	Proportion After =	0.009
Z test Statistic =	-0.67	p(pooled) =	0.008
Critical Statistic =	-1.645	q(pooled) =	0.992

Hence: Reject Ho - Conclude Proportion in After Speed Range is Increased (using Chi-Squared Distribuition)

2. Difference in Proportions - 36 to 47 Speed Range Approach Data Set

$N_{(Before)}$ =	4,406	$N_{(After)}$ =	10,235
Proportion Before =	0.114	Proportion After =	0.251
Z test Statistic =	-18.59	p(pooled) =	0.210
Critical Statistic =	-1.645	q(pooled) =	0.790

Hence: Reject Ho - Conclude Proportion in After Speed Range is increased

3. Difference in Proportions - 48 to 59 Speed Range Approach Data Set

$N_{(Before)}$ =	25,939	$N_{(After)}$ =	27,144
Proportion Before =	0.673	Proportion After =	0.665
Z test Statistic =	2.08	p(pooled) =	0.669
Critical Statistic =	1.645	q(pooled) =	0.331

Hence: Reject Ho - Conclude Proportion in After Speed Range is decreased

4. Difference in Proportions - 60 to 147Speed Range Approach Data Set

$N_{(Before)}$ =	8,040	$N_{(After)}$ =	3,059
Proportion Before =	0.209	Proportion After =	0.075
Z test Statistic =	16.70	p(pooled) =	0.172
Critical Statistic =	1.645	q(pooled) =	0.828

Hence: Reject Ho - Conclude Proportion in After Speed Range is decreased

HYPOTHESIS TEST FOR A DIFFERENCE IN VARIANCE - APPROACH SPEED DATA

To determine if the speed variance decreased after DSM installation.

Ho: $Variance_{(before)} - Variance_{(after)} = 0$ Ha: $Variance_{(before)} - Variance_{(after)} > 0$

Reject Ho if Fstatistic > Critical statistic; 95% significance level

1. Difference in Means - 1 to 35 Speed Range PC Data Set

$N_{(Before)}$ =	130	$N_{(After)}$ =	382
Variance Before =	77.464	Variance After =	19.031
F Statistic =	4.070	Deg. of Free 1, υ_1 =	129
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	381

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

2. Difference in Proportions - 36 to 47 Speed Range PC Data Set

$N_{(Before)}$ =	4,406	$N_{(After)}$ =	10,235
Variance Before =	6.600	Variance After =	7.730
F Statistic =	0.854	Deg. of Free 1, υ_1 =	4405
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	10234

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

3. Difference in Proportions - 48 to 59 Speed Range PC Data Set

$N_{(Before)}$ =	25,939	$N_{(After)}$ =	27,144
Variance Before =	10.298	Variance After =	9.950
F Statistic =	1.035	Deg. of Free 1, υ_1 =	25938
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	27143

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

4. Difference in Proportions - 60 to 147Speed Range PC Data Set

$N_{(Before)}$ =	8,040	$N_{(After)}$ =	3,059
Variance Before =	13.778	Variance After =	11.417
F Statistic =	1.207	Deg. of Free 1, υ_1 =	8039
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	3058

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

BEFORE AND AFTER APPROACH SPEED COMPARISON

Data Set No.	Test No.	DATA SET		Mean		Variance		% Obeying Advisory Speed (35 mph)		% Obeying Speed Limit + 5 Mph		% Obeying Advisory Speed +10 Mph		85th Percentile		Coefficient of Variation	
				Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	1	Entire		54.63	51.05	41.29	37.95	55.95	78.22	83.74	94.44	95.82	98.84	61.0	57.0	0.12	0.12
2	2	Day Time		55.06	51.50	41.41	36.53	52.66	76.26	81.86	93.89	95.25	98.73	61.0	57.0	0.12	0.12
3	3	Night Time		53.75	50.11	39.90	39.62	62.66	82.33	87.59	95.59	97.00	99.05	60.0	56.0	0.12	0.13
3	4	Daily	Monday	54.39	51.50	41.77	36.54	57.51	75.78	84.47	93.73	96.04	98.82	61.0	57.0	0.12	0.12
	5		Tuesday	54.58	51.04	38.34	39.59	56.68	77.79	79.94	93.78	96.22	98.77	61.0	57.0	0.11	0.12
	6		Wednesday	54.96	51.08	43.16	39.20	53.61	77.96	81.97	94.21	94.97	98.96	61.0	57.0	0.12	0.12
	7		Thursday	54.62	51.03	41.91	38.27	56.04	78.20	83.24	94.58	96.13	98.70	61.0	57.0	0.12	0.12
	8		Friday	54.63	50.77	42.88	36.20	55.84	79.87	83.36	95.64	95.38	98.90	61.0	57.0	0.12	0.12
	9		Saturday	54.88	51.06	41.42	38.25	54.63	78.81	83.21	94.24	95.63	98.70	61.0	57.0	0.12	0.12
	10		Sunday	54.31	50.82	38.32	37.29	57.76	79.23	85.60	94.92	96.73	99.03	60.0	57.0	0.11	0.12
4	11	Time of Day	12 MN to 7 AM	53.69	50.62	43.47	44.33	61.79	78.57	86.64	93.89	96.62	98.56	60.0	57.0	0.12	0.13
	12		7 AM to 9 AM	55.09	52.24	46.63	43.04	52.32	71.07	80.61	91.25	94.04	97.76	62.0	59.0	0.12	0.13
	13		9 AM to 11 AM	54.10	51.35	43.91	34.75	58.77	77.99	84.91	94.39	95.86	99.11	61.0	57.0	0.12	0.11
	14		11 AM to 1 PM	54.39	51.57	48.28	37.52	55.51	75.99	83.58	93.33	95.79	98.52	61.0	57.0	0.13	0.12
	15		1 PM to 4 PM	55.38	51.68	38.77	37.02	51.06	74.57	80.72	93.66	94.85	98.79	61.0	58.0	0.11	0.12
	16		4 PM to 6 PM	55.78	51.38	36.70	33.14	48.51	77.34	79.38	94.93	95.08	99.02	62.0	57.0	0.11	0.11
	17		6 PM to 12 MN	54.55	50.31	37.04	35.10	57.60	82.71	85.50	96.11	96.54	99.23	60.0	56.0	0.11	0.12
5	18	Weekday Time of Day	12 MN to 7 AM	53.53	50.66	45.19	40.91	62.14	78.97	86.85	94.09	96.59	98.79	60.0	57.0	0.13	0.13
	19		7 AM to 9 AM	55.20	52.45	48.67	44.17	50.57	70.12	79.88	91.04	94.27	97.53	62.0	59.0	0.13	0.13
	20		9 AM to 11 AM	54.23	51.53	43.30	36.97	57.34	75.98	84.42	94.02	95.73	99.02	61.0	57.0	0.12	0.12
	21		11 AM to 1 PM	54.19	51.70	49.39	37.70	57.69	74.78	83.02	92.67	95.19	98.34	61.0	58.0	0.13	0.12
	22		1 PM to 4 PM	55.32	51.62	39.59	39.57	51.75	74.40	80.77	92.96	94.89	98.64	61.0	58.0	0.11	0.12
	23		4 PM to 6 PM	55.77	51.54	36.19	31.73	49.36	76.99	78.96	94.70	94.97	99.11	62.0	57.0	0.11	0.11
	24		6 PM to 12 MN	54.63	50.47	36.21	36.40	57.15	81.47	85.29	95.72	96.64	99.24	60.0	56.0	0.11	0.12
6	25	Weekend Time of Day	12 MN to 7 AM	54.06	50.49	41.42	52.81	60.65	77.18	86.34	92.62	96.63	98.17	60.0	58.0	0.12	0.14
	26		7 AM to 9 AM	54.79	52.18	43.14	42.87	54.83	70.90	82.62	90.35	94.31	97.70	61.0	59.0	0.12	0.13
	27		9 AM to 11 AM	54.05	51.04	43.06	32.99	60.20	81.08	85.81	94.23	96.39	99.19	60.0	56.0	0.12	0.11
	28		11 AM to 1 PM	54.35	51.41	46.54	36.81	55.42	78.14	84.98	94.08	96.86	98.91	60.3	57.0	0.13	0.12
	29		1 PM to 4 PM	55.40	51.88	36.75	33.80	50.95	73.84	81.29	94.37	95.11	99.06	61.0	58.0	0.11	0.11
	30		4 PM to 6 PM	55.81	51.70	38.13	34.72	47.70	75.39	79.98	93.95	95.09	98.53	62.0	57.0	0.11	0.11
	31		6 PM to 12 MN	54.39	50.02	36.42	33.59	57.99	84.88	85.81	96.60	96.84	99.23	60.0	56.0	0.11	0.12

Data Set No.	Test No.	DATA SET		Mean		Variance		Proportion of Total Vehicles		Coefficient of variation	
								Before	After		
7	32	Speed Range	1 to 35	28.09	32.22	77.46	19.03	0.003	0.009	0.31	0.14
	33		36 to 47	44.37	43.88	6.60	7.73	0.114	0.25	0.058	0.063
	34		48 to 59	53.83	52.69	10.30	9.95	0.673	0.66	0.060	0.060
	35		60 to 147	63.28	62.80	13.78	11.42	0.209	0.07	0.059	0.054

Data Set No.	Test No.	DATA SET		Proportion			Frequency		
				Before	After	Diff.	Before	After	Diff.
8	36	Higher Speed Range	**57 to 59**	16.38	9.44	6.94	6310	3853	2457
	37		**60 to 62**	11.44	4.54	6.90	4406	1853	2553
	38		**63 to 65**	5.26	1.79	3.47	2025	731	1294
	39		**66 to 68**	2.46	0.72	1.74	949	294	655
	40		**69 to 147**	1.71	0.44	1.27	660	181	479

- Indicates no significant reduction at the 95% confidence level

APPENDIX C: PC DATA STATISTICAL ANALYSES

BEFORE AND AFTER PC SPEED COMPARISON

No.	DATA SET		BEFORE								AFTER							
			Total	Mean	Variance	Coefficient of variation	% Obeying Advisory Speed (35 mph)	% Obeying Advisory Speed + 5 Mph	% Obeying Advisory Speed +10 Mph	85th Percentile	Total	Mean	Variance	Coefficient of variation	% Obeying Advisory Speed (35 mph)	% Obeying Advisory Speed + 5 Mph	% Obeying Advisory Speed +10 Mph	85th Percentile
1	Entire		58679	44.15	29.92	0.12	5.07	29.24	54.04	47.00	58881	42.58	29.22	0.13	9.01	40.80	65.79	46.00
2	Day Time		42721	44.85	28.60	0.12	3.59	24.01	48.40	47.00	41978	43.11	29.42	0.13	7.81	35.99	61.39	46.00
3	Night Time		15958	42.29	28.71	0.13	9.04	43.25	69.13	46.00	16903	41.24	26.23	0.12	12.00	52.77	76.70	44.00
4	Daily	Monday	8288	44.04	25.44	0.11	4.09	28.46	55.72	47.00	8293	42.78	28.30	0.12	8.20	39.08	64.56	46.00
5		Tuesday	8640	45.02	30.66	0.12	3.72	24.10	46.83	50.00	8440	42.74	28.26	0.12	8.03	39.06	64.89	46.00
6		Wednesday	8485	45.37	28.77	0.12	3.17	21.25	44.55	49.00	8306	43.89	26.16	0.12	4.86	29.71	56.45	47.00
7		Thursday	8510	45.16	28.50	0.12	3.51	22.29	45.31	47.00	8875	42.44	28.35	0.13	8.59	41.92	67.56	46.00
8		Friday	9559	42.34	34.92	0.14	10.13	44.06	67.97	46.00	9696	41.02	32.87	0.14	16.52	53.31	73.70	44.00
9		Saturday	7852	43.23	27.00	0.12	6.21	34.59	61.27	46.00	7840	42.58	26.94	0.12	7.81	41.38	67.56	46.00
10		Sunday	7345	44.03	24.74	0.11	3.99	28.47	55.86	47.00	7431	42.88	28.18	0.12	7.67	38.85	64.30	46.00
11	Time of Day	12 MN to 7 AM	4575	43.64	33.42	0.13	6.67	34.34	58.34	47.00	5482	42.70	28.24	0.12	7.64	40.77	66.91	46.00
12		7 AM to 9 AM	3121	46.02	30.14	0.12	2.50	18.81	40.02	49.00	2861	44.93	27.01	0.12	2.94	23.94	47.08	47.00
13		9 AM to 11 AM	4015	45.42	27.19	0.11	3.11	19.75	43.54	49.00	3951	44.36	23.96	0.11	3.26	25.59	52.75	47.00
14		11 AM to 1 PM	4981	45.54	27.95	0.12	2.67	19.98	42.84	49.00	4994	44.43	24.23	0.11	3.30	25.91	52.36	47.00
15		1 PM to 4 PM	9867	45.59	25.86	0.11	2.36	18.35	42.56	49.00	9653	44.03	27.08	0.12	4.86	29.44	54.78	47.00
16		4 PM to 6 PM	10096	44.02	29.43	0.12	4.88	29.02	54.39	47.00	9878	41.80	32.44	0.14	13.09	45.79	69.81	46.00
17		6 PM to 12 MN	22024	42.87	28.28	0.12	7.31	38.47	64.57	46.00	22062	41.21	26.19	0.12	12.46	51.84	76.33	44.00
18	Weekday Time of Day	12 MN to 7 AM	2673	44.29	30.93	0.13	4.26	29.82	53.95	47.00	3215	42.96	27.21	0.12	6.56	38.79	64.95	46.00
19		7 AM to 9 AM	1995	46.05	30.66	0.12	2.56	18.55	39.20	49.00	1807	44.95	26.60	0.11	2.77	23.85	47.65	47.00
20		9 AM to 11 AM	2424	45.28	28.87	0.12	3.80	21.37	43.85	47.00	2247	44.61	24.47	0.11	3.20	23.01	50.02	47.00
21		11 AM to 1 PM	2882	45.89	27.79	0.11	2.08	18.29	39.97	49.00	2853	44.54	25.75	0.11	3.54	25.59	51.35	47.00
22		1 PM to 4 PM	5633	46.14	25.96	0.11	1.62	15.76	38.04	49.00	5662	44.40	25.69	0.11	3.74	26.49	51.85	47.00
23		4 PM to 6 PM	5751	45.37	24.33	0.11	2.52	19.79	43.44	47.00	5720	42.94	27.72	0.12	7.64	36.14	63.44	46.00
24		6 PM to 12 MN	12565	43.78	28.54	0.12	5.37	31.06	57.46	47.00	12410	41.34	25.77	0.12	11.61	50.23	75.85	44.00
25	Weekend Time of Day	12 MN to 7 AM	1258	41.62	33.34	0.14	13.04	48.17	71.46	44.00	1474	42.37	31.64	0.13	10.31	43.49	69.20	46.00
26		7 AM to 9 AM	631	45.41	26.31	0.11	2.06	21.87	46.43	49.00	624	44.95	27.12	0.12	2.88	23.72	45.51	47.00
27		9 AM to 11 AM	1011	45.21	22.49	0.10	1.98	18.99	45.90	47.00	1051	43.88	22.55	0.11	3.04	31.21	58.42	46.00
28		11 AM to 1 PM	1303	44.13	23.27	0.11	4.53	24.71	53.49	47.00	1381	44.13	22.29	0.11	3.11	28.10	55.03	47.00
29		1 PM to 4 PM	2675	44.99	23.27	0.11	2.47	20.90	47.14	47.00	2563	43.92	25.58	0.12	4.21	29.89	57.39	47.00
30		4 PM to 6 PM	2246	44.24	22.77	0.11	2.85	25.65	54.36	47.00	2229	43.13	25.55	0.12	5.16	37.01	64.51	46.00
31		6 PM to 12 MN	6073	42.64	24.63	0.12	6.50	39.75	67.17	46.00	5949	41.39	26.61	0.12	12.00	51.02	75.44	44.00
			Total	Mean	Variance	Coefficient of variation	Proportion of Total Vehicles				Total	Mean	Variance	Coefficient of variation	Proportion of Total Vehicles			
32	Speed Range	1 to 35	2977	32.25	10.13	0.10	0.051				5308	32.64	7.58	0.08	0.090			
33		36 to 47	40082	42.41	8.78	0.07	0.683				43195	41.87	9.25	0.07	0.734			
34		48 to 59	15423	50.72	5.46	0.05	0.263				10289	50.49	4.75	0.04	0.175			
35		60 to 147	197	62.26	5.56	0.04	0.003				89	62.04	4.94	0.04	0.002			

HYPOTHESIS TEST FOR A DIFFERENCE IN MEANS - PC SPEED DATA

To determine if the mean speed decreased after DSM installation.

Ho: $Mean_{(before)} - Mean_{(after)} = 0$ **Ha: $Mean_{(before)} - Mean_{(after)} > 0$**

Reject Ho if t test statistic > Critical statistic; 95% significance level

<u>1. Difference in Means - Entire PC Data Set</u>

$N_{(Before)}$ =	58,679	$N_{(After)}$ =	58,881
Mean Before =	44.152	Mean After =	42.576
Variance Before =	29.920	Variance After =	29.222
t test Statistic =	49.691	Deg. of Free, ʋ =	117531
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

<u>2. Difference in Means - Day Time PC Data Set</u>

$N_{(Before)}$ =	42,721	$N_{(After)}$ =	41,978
Mean Before =	44.847	Mean After =	43.114
Variance Before =	28.598	Variance After =	29.419
t test Statistic =	46.823	Deg. of Free, ʋ =	84612
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

<u>3. Difference in Means - Night Time PC Data Set</u>

$N_{(Before)}$ =	15,958	$N_{(After)}$ =	16,903
Mean Before =	42.293	Mean After =	41.24
Variance Before =	28.711	Variance After =	26.23
t test Statistic =	18.168	Deg. of Free, ʋ =	32517
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

<u>4. Difference in Means - Daily Monday PC Data Set</u>

$N_{(Before)}$ =	8,288	$N_{(After)}$ =	8,293
Mean Before =	44.036	Mean After =	42.785
Variance Before =	25.442	Variance After =	28.303
t test Statistic =	15.542	Deg. of Free, ʋ =	16533
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

<u>5. Difference in Means - Daily Tuesday PC Data Set</u>

$N_{(Before)}$ =	8,640	$N_{(After)}$ =	8,440
Mean Before =	45.023	Mean After =	42.739
Variance Before =	30.660	Variance After =	28.263
t test Statistic =	27.513	Deg. of Free, ʋ =	17073
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

6. Difference in Means - Daily Wednesday PC Data Set

$N_{(Before)}$ =	8,485	$N_{(After)}$ =	8,306
Mean Before =	45.369	Mean After =	43.891
Variance Before =	28.766	Variance After =	26.157
t test Statistic =	18.266	Deg. of Free, υ =	16777
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

7. Difference in Means - Daily Thursday PC Data Set

$N_{(Before)}$ =	8,510	$N_{(After)}$ =	8,875
Mean Before =	45.155	Mean After =	42.438
Variance Before =	28.495	Variance After =	28.355
t test Statistic =	33.594	Deg. of Free, υ =	17349
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

8. Difference in Means - Daily Friday PC Data Set

$N_{(Before)}$ =	9,559	$N_{(After)}$ =	9,696
Mean Before =	42.342	Mean After =	41.023
Variance Before =	34.917	Variance After =	32.865
t test Statistic =	15.712	Deg. of Free, υ =	19215
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

9. Difference in Means - Daily Saturday PC Data Set

$N_{(Before)}$ =	7,852	$N_{(After)}$ =	7,840
Mean Before =	43.231	Mean After =	42.579
Variance Before =	27.001	Variance After =	26.943
t test Statistic =	7.863	Deg. of Free, υ =	15690
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

10. Difference in Means - Daily Sunday PC Data Set

$N_{(Before)}$ =	7,345	$N_{(After)}$ =	7,431
Mean Before =	44.033	Mean After =	42.877
Variance Before =	24.736	Variance After =	28.178
t test Statistic =	13.665	Deg. of Free, υ =	14732
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

11. Difference in Means - TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	4,575	$N_{(After)}$ =	5,482
Mean Before =	43.638	Mean After =	42.701
Variance Before =	33.423	Variance After =	28.244
t test Statistic =	8.397	Deg. of Free, υ =	9399
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

12. Difference in Means - TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	3,121	$N_{(After)}$ =	2,861
Mean Before =	46.022	Mean After =	44.931
Variance Before =	30.142	Variance After =	27.012
t test Statistic =	7.891	Deg. of Free, υ =	5974
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

13. Difference in Means - TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	4,015	$N_{(After)}$ =	3,951
Mean Before =	45.419	Mean After =	44.364
Variance Before =	27.191	Variance After =	23.959
t test Statistic =	9.311	Deg. of Free, υ =	7946
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

14. Difference in Means - TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	4,981	$N_{(After)}$ =	4,994
Mean Before =	45.543	Mean After =	44.426
Variance Before =	27.948	Variance After =	24.232
t test Statistic =	10.920	Deg. of Free, υ =	9919
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

15. Difference in Means - TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	9,867	$N_{(After)}$ =	9,653
Mean Before =	45.588	Mean After =	44.031
Variance Before =	25.857	Variance After =	27.077
t test Statistic =	21.146	Deg. of Free, υ =	19479
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

16. Difference in Means - TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ = 10,096	$N_{(After)}$ = 9,878
Mean Before = 44.022	Mean After = 41.800
Variance Before = 29.426	Variance After = 32.443
t test Statistic = 28.216	Deg. of Free, υ = 19873
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

17. Difference in Means - TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 22,024	$N_{(After)}$ = 22,062
Mean Before = 42.866	Mean After = 41.212
Variance Before = 28.284	Variance After = 26.193
t test Statistic = 33.262	Deg. of Free, υ = 44013
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

18. Difference in Means - Weekday TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 2,673	$N_{(After)}$ = 3,215
Mean Before = 44.288	Mean After = 42.963
Variance Before = 30.930	Variance After = 27.209
t test Statistic = 9.359	Deg. of Free, υ = 5544
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

19. Difference in Means - Weekday TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 1,995	$N_{(After)}$ = 1,807
Mean Before = 46.052	Mean After = 44.948
Variance Before = 30.658	Variance After = 26.595
t test Statistic = 6.364	Deg. of Free, υ = 3797
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

20. Difference in Means - Weekday TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 2,424	$N_{(After)}$ = 2,247
Mean Before = 45.284	Mean After = 44.613
Variance Before = 28.872	Variance After = 24.472
t test Statistic = 4.445	Deg. of Free, υ = 4669
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

21. Difference in Means - Weekday TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 2,882	$N_{(After)}$ = 2,853
Mean Before = 45.887	Mean After = 44.535
Variance Before = 27.790	Variance After = 25.753
t test Statistic = 9.894	Deg. of Free, υ = 5729
Critical Statistic = 1.645	

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

22. Difference in Means - Weekday TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	5,633	$N_{(After)}$ =	5,662
Mean Before =	46.141	Mean After =	44.401
Variance Before =	25.961	Variance After =	25.693
t test Statistic =	18.194	Deg. of Free, ʋ =	11292
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

23. Difference in Means - Weekday TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	5,751	$N_{(After)}$ =	5,720
Mean Before =	45.366	Mean After =	42.945
Variance Before =	24.327	Variance After =	27.717
t test Statistic =	25.409	Deg. of Free, ʋ =	11412
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

24. Difference in Means - Weekday TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	12,565	$N_{(After)}$ =	12,410
Mean Before =	43.782	Mean After =	41.340
Variance Before =	28.535	Variance After =	25.765
t test Statistic =	37.031	Deg. of Free, ʋ =	24936
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

25. Difference in Means - Weekend TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	1,258	$N_{(After)}$ =	1,474
Mean Before =	41.619	Mean After =	42.365
Variance Before =	33.339	Variance After =	31.639
t test Statistic =	-3.408	Deg. of Free, ʋ =	2640
Critical Statistic =	1.645		

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

26. Difference in Means - Weekend TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	631	$N_{(After)}$ =	624
Mean Before =	45.408	Mean After =	44.954
Variance Before =	26.313	Variance After =	27.124
t test Statistic =	1.558	Deg. of Free, ʋ =	1252
Critical Statistic =	1.645		

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

27. Difference in Means - Weekend TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	1,011	$N_{(After)}$ =	1,051
Mean Before =	45.206	Mean After =	43.878
Variance Before =	22.486	Variance After =	22.547
t test Statistic =	6.355	Deg. of Free, ʋ =	2057
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

28. Difference in Means - Weekend TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	1,303	$N_{(After)}$ =	1,381
Mean Before =	44.130	Mean After =	44.125
Variance Before =	23.273	Variance After =	22.290
t test Statistic =	0.026	Deg. of Free, υ =	2665
Critical Statistic =	1.645		

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

29. Difference in Means - Weeend TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	2,675	$N_{(After)}$ =	2,563
Mean Before =	44.987	Mean After =	43.917
Variance Before =	23.269	Variance After =	25.580
t test Statistic =	7.829	Deg. of Free, υ =	5194
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

30. Difference in Means - Weekend TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	2,246	$N_{(After)}$ =	2,229
Mean Before =	44.236	Mean After =	43.127
Variance Before =	22.770	Variance After =	25.553
t test Statistic =	7.546	Deg. of Free, υ =	4454
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

31. Difference in Means - Weekend TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	6,073	$N_{(After)}$ =	5,949
Mean Before =	42.642	Mean After =	41.385
Variance Before =	24.628	Variance After =	26.614
t test Statistic =	13.612	Deg. of Free, υ =	11978
Critical Statistic =	1.645		

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN VARIANCE - PC SPEED DATA

To determine if the speed variance decreased after DSM installation.

Ho: $Variance_{(before)} - Variance_{(after)} = 0$ **Ha: $Variance_{(before)} - Variance_{(after)} > 0$**

Reject Ho if Fstatistic > Critical statistic; 95% significance level

1. Difference in Variance - Entire PC Data Set

$N_{(Before)}$ =	58,679	$N_{(After)}$ =	58,881
Variance Before =	29.920	Variance After =	29.222
F Statistic =	1.024	Deg. of Free 1, υ_1 =	58678
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	58880

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

2. Difference in Variance - Day Time PC Data Set

$N_{(Before)}$ =	42,721	$N_{(After)}$ =	41,978
Variance Before =	28.598	Variance After =	29.419
F Statistic =	0.972	Deg. of Free 1, υ_1 =	42720
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	41977

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

3. Difference in Variance - Night Time PC Data Set

$N_{(Before)}$ =	15,958	$N_{(After)}$ =	16,903
Variance Before =	28.711	Variance After =	26.232
F Statistic =	1.095	Deg. of Free 1, υ_1 =	15957
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	16902

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

4. Difference in Variance - Daily Monday PC Data Set

$N_{(Before)}$ =	8,288	$N_{(After)}$ =	8,293
Variance Before =	25.442	Variance After =	28.303
F Statistic =	0.899	Deg. of Free 1, υ_1 =	8287
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	8292

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

5. Difference in Variance - Daily Tuesday PC Data Set

$N_{(Before)}$ =	8,640	$N_{(After)}$ =	8,440
Variance Before =	30.660	Variance After =	28.263
F Statistic =	1.085	Deg. of Free 1, υ_1 =	8639
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	8439

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

6. Difference in Variance - Daily Wednesday PC Data Set

$N_{(Before)}$ = 8,485 | $N_{(After)}$ = 8,306

Variance Before = 28.766 | Variance After = 26.157

F Statistic = 1.100 | Deg. of Free 1, υ_1 = 8484

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 8305

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

7. Difference in Variance - Daily Thursday PC Data Set

$N_{(Before)}$ = 8,510 | $N_{(After)}$ = 8,875

Variance Before = 28.495 | Variance After = 28.355

F Statistic = 1.005 | Deg. of Free 1, υ_1 = 8509

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 8874

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

8. Difference in Variance - Daily Friday PC Data Set

$N_{(Before)}$ = 9,559 | $N_{(After)}$ = 9,696

Variance Before = 34.917 | Variance After = 32.865

F Statistic = 1.062 | Deg. of Free 1, υ_1 = 9558

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 9695

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

9. Difference in Variance - Daily Saturday PC Data Set

$N_{(Before)}$ = 7,852 | $N_{(After)}$ = 7,840

Variance Before = 27.001 | Variance After = 26.943

F Statistic = 1.002 | Deg. of Free 1, υ_1 = 7851

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 7839

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

10. Difference in Variance - Daily Sunday PC Data Set

$N_{(Before)}$ = 7,345 | $N_{(After)}$ = 7,431

Variance Before = 24.736 | Variance After = 28.178

F Statistic = 0.878 | Deg. of Free 1, υ_1 = 7344

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 7430

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

11. Difference in Variance - TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 4,575 | $N_{(After)}$ = 5,482

Variance Before = 33.423 | Variance After = 28.244

F Statistic = 1.183 | Deg. of Free 1, υ_1 = 4574

Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 5481

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

12. Difference in Variance - TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 3,121 | $N_{(After)}$ = 2,861
Variance Before = 30.142 | Variance After = 27.012

F Statistic = 1.116 | Deg. of Free 1, υ_1 = 3120
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 2860

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

13. Difference in Variance - TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 4,015 | $N_{(After)}$ = 3,951
Variance Before = 27.191 | Variance After = 23.959

F Statistic = 1.135 | Deg. of Free 1, υ_1 = 4014
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 3950

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

14. Difference in Variance - TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 4,981 | $N_{(After)}$ = 4,994
Variance Before = 27.948 | Variance After = 24.232

F Statistic = 1.153 | Deg. of Free 1, υ_1 = 4980
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 4993

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

15. Difference in Variance - TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ = 9,867 | $N_{(After)}$ = 9,653
Variance Before = 25.857 | Variance After = 27.077

F Statistic = 0.955 | Deg. of Free 1, υ_1 = 9866
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 9652

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

16. Difference in Variance - TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ = 10,096 | $N_{(After)}$ = 9,878
Variance Before = 29.426 | Variance After = 32.443

F Statistic = 0.907 | Deg. of Free 1, υ_1 = 10095
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 9877

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

17. Difference in Variance - TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 22,024 | $N_{(After)}$ = 22,062
Variance Before = 28.284 | Variance After = 26.193

F Statistic = 1.080 | Deg. of Free 1, υ_1 = 22023
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 22061

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

18. Difference in Variance - Weekday TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	2,673	$N_{(After)}$ =	3,215
Variance Before =	30.930	Variance After =	27.209
F Statistic =	1.137	Deg. of Free 1, υ_1 =	2672
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	3214

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

19. Difference in Variance - Weekday TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	1,995	$N_{(After)}$ =	1,807
Variance Before =	30.658	Variance After =	26.595
F Statistic =	1.153	Deg. of Free 1, υ_1 =	1994
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	1806

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

20. Difference in Variance - Weekday TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	2,424	$N_{(After)}$ =	2,247
Variance Before =	28.872	Variance After =	24.472
F Statistic =	1.180	Deg. of Free 1, υ_1 =	2423
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	2246

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

21. Difference in Variance - Weekday TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	2,882	$N_{(After)}$ =	2,853
Variance Before =	27.790	Variance After =	25.753
F Statistic =	1.079	Deg. of Free 1, υ_1 =	2881
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	2852

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

22. Difference in Variance - Weekday TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	5,633	$N_{(After)}$ =	5,662
Variance Before =	25.961	Variance After =	25.693
F Statistic =	1.010	Deg. of Free 1, υ_1 =	5632
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	5661

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

23. Difference in Variance - Weekday TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	5,751	$N_{(After)}$ =	5,720
Variance Before =	24.327	Variance After =	27.717
F Statistic =	0.878	Deg. of Free 1, υ_1 =	5750
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	5719

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

24. Difference in Variance - Weekday TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 12,565 | $N_{(After)}$ = 12,410
Variance Before = 28.535 | Variance After = 25.765

F Statistic = 1.108 | Deg. of Free 1, υ_1 = 12564
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 12409

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

25. Difference in Variance - Weekend TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 1,258 | $N_{(After)}$ = 1,474
Variance Before = 33.339 | Variance After = 31.639

F Statistic = 1.054 | Deg. of Free 1, υ_1 = 1257
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 1473

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

26. Difference in Variance - Weekend TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 631 | $N_{(After)}$ = 624
Variance Before = 26.313 | Variance After = 27.124

F Statistic = 0.970 | Deg. of Free 1, υ_1 = 630
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 623

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

27. Difference in Variance - Weekend TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 1,011 | $N_{(After)}$ = 1,051
Variance Before = 22.486 | Variance After = 22.547

F Statistic = 0.997 | Deg. of Free 1, υ_1 = 1010
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 1050

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

28. Difference in Variance - Weekend TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 1,303 | $N_{(After)}$ = 1,381
Variance Before = 23.273 | Variance After = 22.290

F Statistic = 1.044 | Deg. of Free 1, υ_1 = 1302
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 1380

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

29. Difference in Variance - Weeend TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	2,675	$N_{(After)}$ =	2,563
Variance Before =	23.269	Variance After =	25.580
F Statistic =	0.910	Deg. of Free 1, υ_1 =	2674
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	2562

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

30. Difference in Variance - Weekend TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	2,246	$N_{(After)}$ =	2,229
Variance Before =	22.770	Variance After =	25.553
F Statistic =	0.891	Deg. of Free 1, υ_1 =	2245
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	2228

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

31. Difference in Variance - Weekend TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	6,073	$N_{(After)}$ =	5,949
Variance Before =	24.628	Variance After =	26.614
F Statistic =	0.925	Deg. of Free 1, υ_1 =	6072
Critical Statistic =	1.00	Deg. of Free 2, υ_2 =	5948

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - PC SPEED DATA
COMPLIANCE WITH ADVISORY SPEED - 35 MPH

To determine if the proportion of drivers complying with the advisory speed of 35 mph increased after DSM installation.

Ho: $\text{Proportion}_{(before)}$ - $\text{Proportion}_{(after)}$ = 0 **Ha: $\text{Proportion}_{(before)}$ - $\text{Proportion}_{(after)}$ < 0**

Reject Ho if Z statistic test < Critical statistic; 95% significance level

1. Difference in Proportions - Entire PC Data Set

$N_{(Before)}$ = 58,679 $N_{(After)}$ = 58,881
Proportion Before = 0.051 Proportion After = 0.090

Z test Statistic = -26.40 p(pooled) = 0.070
Critical Statistic = -1.645 q(pooled) = 0.930

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

2. Difference in Proportions - Day Time PC Data Set

$N_{(Before)}$ = 42,721 $N_{(After)}$ = 41,978
Proportion Before = 0.036 Proportion After = 0.078

Z test Statistic = -26.53 p(pooled) = 0.057
Critical Statistic = -1.645 q(pooled) = 0.943

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

3. Difference in Proportions - Night Time PC Data Set

$N_{(Before)}$ = 15,958 $N_{(After)}$ = 16,903
Proportion Before = 0.090 Proportion After = 0.120

Z test Statistic = -8.73 p(pooled) = 0.106
Critical Statistic = -1.645 q(pooled) = 0.894

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

4. Difference in Proportions - Daily Monday PC Data Set

$N_{(Before)}$ = 8,288 $N_{(After)}$ = 8,293
Proportion Before = 0.041 Proportion After = 0.082

Z test Statistic = -11.02 p(pooled) = 0.061
Critical Statistic = -1.645 q(pooled) = 0.939

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday PC Data Set

$N_{(Before)}$ = 8,640 $N_{(After)}$ = 8,440
Proportion Before = 0.037 Proportion After = 0.080

Z test Statistic = -12.02 p(pooled) = 0.058
Critical Statistic = -1.645 q(pooled) = 0.942

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday PC Data Set

$N_{(Before)}$ =	8,485	$N_{(After)}$ =	8,306
Proportion Before =	0.032	Proportion After =	0.049
Z test Statistic =	-5.59	p(pooled) =	0.040
Critical Statistic =	-1.645	q(pooled) =	0.960

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

7. Difference in Proportions - Daily Thursday PC Data Set

$N_{(Before)}$ =	8,510	$N_{(After)}$ =	8,875
Proportion Before =	0.035	Proportion After =	0.086
Z test Statistic =	-13.97	p(pooled) =	0.061
Critical Statistic =	-1.645	q(pooled) =	0.939

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

8. Difference in Proportions - Daily Friday PC Data Set

$N_{(Before)}$ =	9,559	$N_{(After)}$ =	9,696
Proportion Before =	0.101	Proportion After =	0.165
Z test Statistic =	-13.05	p(pooled) =	0.133
Critical Statistic =	-1.645	q(pooled) =	0.867

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

9. Difference in Proportions - Daily Saturday PC Data Set

$N_{(Before)}$ =	7,852	$N_{(After)}$ =	7,840
Proportion Before =	0.062	Proportion After =	0.078
Z test Statistic =	-3.90	p(pooled) =	0.070
Critical Statistic =	-1.645	q(pooled) =	0.930

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

10. Difference in Proportions - Daily Sunday PC Data Set

$N_{(Before)}$ =	7,345	$N_{(After)}$ =	7,431
Proportion Before =	0.040	Proportion After =	0.077
Z test Statistic =	-9.54	p(pooled) =	0.058
Critical Statistic =	-1.645	q(pooled) =	0.942

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	4,575	$N_{(After)}$ =	5,482
Proportion Before =	0.067	Proportion After =	0.076
Z test Statistic =	-1.89	p(pooled) =	0.072
Critical Statistic =	-1.645	q(pooled) =	0.928

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	3,121	$N_{(After)}$ =	2,861
Proportion Before =	0.025	Proportion After =	0.029
Z test Statistic =	-1.04	p(pooled) =	0.027
Critical Statistic =	-1.645	q(pooled) =	0.973

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

13. Difference in Proportions - TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	4,015	$N_{(After)}$ =	3,951
Proportion Before =	0.031	Proportion After =	0.033
Z test Statistic =	-0.39	p(pooled) =	0.032
Critical Statistic =	-1.645	q(pooled) =	0.968

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

14. Difference in Proportions - TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	4,981	$N_{(After)}$ =	4,994
Proportion Before =	0.027	Proportion After =	0.033
Z test Statistic =	-1.86	p(pooled) =	0.030
Critical Statistic =	-1.645	q(pooled) =	0.970

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	9,867	$N_{(After)}$ =	9,653
Proportion Before =	0.024	Proportion After =	0.049
Z test Statistic =	-9.37	p(pooled) =	0.036
Critical Statistic =	-1.645	q(pooled) =	0.964

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	10,096	$N_{(After)}$ =	9,878
Proportion Before =	0.049	Proportion After =	0.131
Z test Statistic =	-20.32	p(pooled) =	0.089
Critical Statistic =	-1.645	q(pooled) =	0.911

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 22,024 $N_{(After)}$ = 22,062
Proportion Before = 0.073 Proportion After = 0.125

Z test Statistic = -18.11 p(pooled) = 0.099
Critical Statistic = -1.645 q(pooled) = 0.901

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 2,673 $N_{(After)}$ = 3,215
Proportion Before = 0.043 Proportion After = 0.066

Z test Statistic = -3.84 p(pooled) = 0.055
Critical Statistic = -1.645 q(pooled) = 0.945

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 1,995 $N_{(After)}$ = 1,807
Proportion Before = 0.026 Proportion After = 0.028

Z test Statistic = -0.40 p(pooled) = 0.027
Critical Statistic = -1.645 q(pooled) = 0.973

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 2,424 $N_{(After)}$ = 2,247
Proportion Before = 0.038 Proportion After = 0.032

Z test Statistic = 1.10 p(pooled) = 0.035
Critical Statistic = -1.645 q(pooled) = 0.965

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 2,882 $N_{(After)}$ = 2,853
Proportion Before = 0.021 Proportion After = 0.035

Z test Statistic = -3.34 p(pooled) = 0.028
Critical Statistic = -1.645 q(pooled) = 0.972

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ = 5,633 $N_{(After)}$ = 5,662
Proportion Before = 0.016 Proportion After = 0.037

Z test Statistic = -7.00 p(pooled) = 0.027
Critical Statistic = -1.645 q(pooled) = 0.973

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	5,751		$N_{(After)}$ =	5,720	
Proportion Before =	0.025		Proportion After =		0.076
Z test Statistic =	-12.49		p(pooled) =	0.051	
Critical Statistic =	-1.645		q(pooled) =	0.949	

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	12,565		$N_{(After)}$ =	12,410	
Proportion Before =	0.054		Proportion After =		0.116
Z test Statistic =	-17.70		p(pooled) =	0.085	
Critical Statistic =	-1.645		q(pooled) =	0.915	

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	1,258		$N_{(After)}$ =	1,474	
Proportion Before =	0.130		Proportion After =		0.103
Z test Statistic =	2.22		p(pooled) =	0.116	
Critical Statistic =	-1.645		q(pooled) =	0.884	

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	631		$N_{(After)}$ =	624	
Proportion Before =	0.021		Proportion After =		0.029
Z test Statistic =	-0.94		p(pooled) =	0.025	
Critical Statistic =	-1.645		q(pooled) =	0.975	

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	1,011		$N_{(After)}$ =	1,051	
Proportion Before =	0.020		Proportion After =		0.030
Z test Statistic =	-1.54		p(pooled) =	0.025	
Critical Statistic =	-1.645		q(pooled) =	0.975	

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	1,303		$N_{(After)}$ =	1,381	
Proportion Before =	0.045		Proportion After =		0.031
Z test Statistic =	1.92		p(pooled) =	0.038	
Critical Statistic =	-1.645		q(pooled) =	0.962	

Hence: Accept Ho - Conclude 35 mph Advisory Speed Compliance is not increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	2,675	$N_{(After)}$ =	2,563
Proportion Before =	0.025	Proportion After =	0.042
Z test Statistic =	-3.53	p(pooled) =	0.033
Critical Statistic =	-1.645	q(pooled) =	0.967

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	2,246	$N_{(After)}$ =	2,229
Proportion Before =	0.028	Proportion After =	0.052
Z test Statistic =	-3.94	p(pooled) =	0.040
Critical Statistic =	-1.645	q(pooled) =	0.960

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	6,073	$N_{(After)}$ =	5,949
Proportion Before =	0.065	Proportion After =	0.120
Z test Statistic =	-10.42	p(pooled) =	0.092
Critical Statistic =	-1.645	q(pooled) =	0.908

Hence: Reject Ho - Conclude 35 mph Advisory Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - PC SPEED DATA COMPLIANCE WITH ADVISORY SPEED + 5 MPH

To determine if the proportion of drivers complying with the advisory speed of 35 mph + 5 mph increased after DSM installation.

Ho: $Proportion_{(before)} - Proportion_{(after)} = 0$ **Ha: $Proportion_{(before)} - Proportion_{(after)} < 0$**

Reject Ho if Z test statistic < Critical statistic; 95% significance level

1. Difference in Proportions - Entire PC Data Set

$N_{(Before)}$ =	58,679	$N_{(After)}$ =	58,881
Proportion Before =	0.292	Proportion After =	0.408
Z test Statistic =	-41.54	p(pooled) =	0.350
Critical Statistic =	-1.645	q(pooled) =	0.650

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

2. Difference in Proportions - Day Time PC Data Set

$N_{(Before)}$ =	42,721	$N_{(After)}$ =	41,978
Proportion Before =	0.240	Proportion After =	0.360
Z test Statistic =	-38.05	p(pooled) =	0.299
Critical Statistic =	-1.645	q(pooled) =	0.701

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

3. Difference in Proportions - Night Time PC Data Set

$N_{(Before)}$ =	15,958	$N_{(After)}$ =	16,903
Proportion Before =	0.433	Proportion After =	0.528
Z test Statistic =	-17.25	p(pooled) =	0.481
Critical Statistic =	-1.645	q(pooled) =	0.519

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

4. Difference in Proportions - Daily Monday PC Data Set

$N_{(Before)}$ =	8,288	$N_{(After)}$ =	8,293
Proportion Before =	0.285	Proportion After =	0.391
Z test Statistic =	-14.46	p(pooled) =	0.338
Critical Statistic =	-1.645	q(pooled) =	0.662

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday PC Data Set

$N_{(Before)}$ =	8,640	$N_{(After)}$ =	8,440
Proportion Before =	0.241	Proportion After =	0.391
Z test Statistic =	-21.05	p(pooled) =	0.315
Critical Statistic =	-1.645	q(pooled) =	0.685

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday PC Data Set

$N_{(Before)}$ =	8,485	$N_{(After)}$ =	8,306
Proportion Before =	0.212	Proportion After =	0.297
Z test Statistic =	-12.59	p(pooled) =	0.254
Critical Statistic =	-1.645	q(pooled) =	0.746

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

7. Difference in Proportions - Daily Thursday PC Data Set

$N_{(Before)}$ =	8,510	$N_{(After)}$ =	8,875
Proportion Before =	0.223	Proportion After =	0.419
Z test Statistic =	-27.66	p(pooled) =	0.323
Critical Statistic =	-1.645	q(pooled) =	0.677

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

8. Difference in Proportions - Daily Friday PC Data Set

$N_{(Before)}$ =	9,559	$N_{(After)}$ =	9,696
Proportion Before =	0.441	Proportion After =	0.533
Z test Statistic =	-12.84	p(pooled) =	0.487
Critical Statistic =	-1.645	q(pooled) =	0.513

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

9. Difference in Proportions - Daily Saturday PC Data Set

$N_{(Before)}$ =	7,852	$N_{(After)}$ =	7,840
Proportion Before =	0.346	Proportion After =	0.414
Z test Statistic =	-8.76	p(pooled) =	0.380
Critical Statistic =	-1.645	q(pooled) =	0.620

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

10. Difference in Proportions - Daily Sunday PC Data Set

$N_{(Before)}$ =	7,345	$N_{(After)}$ =	7,431
Proportion Before =	0.285	Proportion After =	0.389
Z test Statistic =	-13.35	p(pooled) =	0.337
Critical Statistic =	-1.645	q(pooled) =	0.663

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	4,575	$N_{(After)}$ =	5,482
Proportion Before =	0.343	Proportion After =	0.408
Z test Statistic =	-6.62	p(pooled) =	0.378
Critical Statistic =	-1.645	q(pooled) =	0.622

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	3,121	$N_{(After)}$ =	2,861
Proportion Before =	0.188	Proportion After =	0.239
Z test Statistic =	-4.85	p(pooled) =	0.213
Critical Statistic =	-1.645	q(pooled) =	0.787

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

13. Difference in Proportions - TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	4,015	$N_{(After)}$ =	3,951
Proportion Before =	0.198	Proportion After =	0.256
Z test Statistic =	-6.22	p(pooled) =	0.226
Critical Statistic =	-1.645	q(pooled) =	0.774

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

14. Difference in Proportions - TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	4,981	$N_{(After)}$ =	4,994
Proportion Before =	0.200	Proportion After =	0.259
Z test Statistic =	-7.05	p(pooled) =	0.229
Critical Statistic =	-1.645	q(pooled) =	0.771

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	9,867	$N_{(After)}$ =	9,653
Proportion Before =	0.184	Proportion After =	0.294
Z test Statistic =	-18.18	p(pooled) =	0.238
Critical Statistic =	-1.645	q(pooled) =	0.762

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	10,096	$N_{(After)}$ =	9,878
Proportion Before =	0.290	Proportion After =	0.458
Z test Statistic =	-24.50	p(pooled) =	0.373
Critical Statistic =	-1.645	q(pooled) =	0.627

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	22,024	$N_{(After)}$ =	22,062
Proportion Before =	0.385	Proportion After =	0.518
Z test Statistic =	-28.19	p(pooled) =	0.452
Critical Statistic =	-1.645	q(pooled) =	0.548

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	2,673	$N_{(After)}$ =	3,215
Proportion Before =	0.298	Proportion After =	0.388
Z test Statistic =	-7.20	p(pooled) =	0.347
Critical Statistic =	-1.645	q(pooled) =	0.653

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	1,995	$N_{(After)}$ =	1,807
Proportion Before =	0.185	Proportion After =	0.239
Z test Statistic =	-4.01	p(pooled) =	0.211
Critical Statistic =	-1.645	q(pooled) =	0.789

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	2,424	$N_{(After)}$ =	2,247
Proportion Before =	0.214	Proportion After =	0.230
Z test Statistic =	-1.35	p(pooled) =	0.222
Critical Statistic =	-1.645	q(pooled) =	0.778

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	2,882	$N_{(After)}$ =	2,853
Proportion Before =	0.183	Proportion After =	0.256
Z test Statistic =	-6.68	p(pooled) =	0.219
Critical Statistic =	-1.645	q(pooled) =	0.781

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	5,633	$N_{(After)}$ =	5,662
Proportion Before =	0.158	Proportion After =	0.265
Z test Statistic =	-13.96	p(pooled) =	0.211
Critical Statistic =	-1.645	q(pooled) =	0.789

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	5,751	$N_{(After)}$ =	5,720
Proportion Before =	0.198	Proportion After =	0.361
Z test Statistic =	-19.51	p(pooled) =	0.279
Critical Statistic =	-1.645	q(pooled) =	0.721

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 12,565 | $N_{(After)}$ = 12,410
Proportion Before = 0.311 | Proportion After = 0.502

Z test Statistic = -30.85 | p(pooled) = 0.406
Critical Statistic = -1.645 | q(pooled) = 0.594

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 1,258 | $N_{(After)}$ = 1,474
Proportion Before = 0.482 | Proportion After = 0.435

Z test Statistic = 2.45 | p(pooled) = 0.456
Critical Statistic = -1.645 | q(pooled) = 0.544

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 631 | $N_{(After)}$ = 624
Proportion Before = 0.219 | Proportion After = 0.237

Z test Statistic = -0.78 | p(pooled) = 0.228
Critical Statistic = -1.645 | q(pooled) = 0.772

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 1,011 | $N_{(After)}$ = 1,051
Proportion Before = 0.190 | Proportion After = 0.312

Z test Statistic = -6.39 | p(pooled) = 0.252
Critical Statistic = -1.645 | q(pooled) = 0.748

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 1,303 | $N_{(After)}$ = 1,381
Proportion Before = 0.247 | Proportion After = 0.281

Z test Statistic = -1.99 | p(pooled) = 0.265
Critical Statistic = -1.645 | q(pooled) = 0.735

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ = 2,675 | $N_{(After)}$ = 2,563
Proportion Before = 0.209 | Proportion After = 0.299

Z test Statistic = -7.48 | p(pooled) = 0.253
Critical Statistic = -1.645 | q(pooled) = 0.747

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	2,246	$N_{(After)}$ =	2,229
Proportion Before =	0.256	Proportion After =	0.370
Z test Statistic =	-8.20	p(pooled) =	0.313
Critical Statistic =	-1.645	q(pooled) =	0.687

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	6,073	$N_{(After)}$ =	5,949
Proportion Before =	0.397	Proportion After =	0.510
Z test Statistic =	-12.41	p(pooled) =	0.453
Critical Statistic =	-1.645	q(pooled) =	0.547

Hence: Reject Ho - Conclude 35 + 5 mph Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - PC SPEED DATA COMPLIANCE WITH ADVISORY SPEED + 10 MPH

To determine if the proportion of drivers complying with the advisory speed of 35 mph + 10 mph increased after DSM installation.

Ho: $\text{Proportion}_{(before)} - \text{Proportion}_{(after)} = 0$ **Ha: $\text{Proportion}_{(before)} - \text{Proportion}_{(after)} < 0$**

Reject Ho if Z test statistic < Critical statistic; 95% significance level

1. Difference in Proportions - Entire PC Data Set

$N_{(Before)}$ =	58,679	$N_{(After)}$ =	58,881
Proportion Before =	0.540	Proportion After =	0.658
Z test Statistic =	-41.10	p(pooled) =	0.599
Critical Statistic =	-1.645	q(pooled) =	0.401

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

2. Difference in Proportions - Day Time PC Data Set

$N_{(Before)}$ =	42,721	$N_{(After)}$ =	41,978
Proportion Before =	0.484	Proportion After =	0.614
Z test Statistic =	-37.98	p(pooled) =	0.548
Critical Statistic =	-1.645	q(pooled) =	0.452

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

3. Difference in Proportions - Night Time PC Data Set

$N_{(Before)}$ =	15,958	$N_{(After)}$ =	16,903
Proportion Before =	0.691	Proportion After =	0.767
Z test Statistic =	-15.45	p(pooled) =	0.730
Critical Statistic =	-1.645	q(pooled) =	0.270

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

4. Difference in Proportions - Daily Monday PC Data Set

$N_{(Before)}$ =	8,288	$N_{(After)}$ =	8,293
Proportion Before =	0.557	Proportion After =	0.646
Z test Statistic =	-11.63	p(pooled) =	0.601
Critical Statistic =	-1.645	q(pooled) =	0.399

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

5. Difference in Proportions - Daily Tuesday PC Data Set

$N_{(Before)}$ =	8,640	$N_{(After)}$ =	8,440
Proportion Before =	0.468	Proportion After =	0.649
Z test Statistic =	-23.77	p(pooled) =	0.558
Critical Statistic =	-1.645	q(pooled) =	0.442

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

6. Difference in Proportions - Daily Wednesday PC Data Set

$N_{(Before)}$ = 8,485 | $N_{(After)}$ = 8,306
Proportion Before = 0.445 | Proportion After = 0.565

Z test Statistic = -15.42 | p(pooled) = 0.504
Critical Statistic = -1.645 | q(pooled) = 0.496

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

7. Difference in Proportions - Daily Thursday PC Data Set

$N_{(Before)}$ = 8,510 | $N_{(After)}$ = 8,875
Proportion Before = 0.453 | Proportion After = 0.676

Z test Statistic = -29.59 | p(pooled) = 0.567
Critical Statistic = -1.645 | q(pooled) = 0.433

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

8. Difference in Proportions - Daily Friday PC Data Set

$N_{(Before)}$ = 9,559 | $N_{(After)}$ = 9,696
Proportion Before = 0.680 | Proportion After = 0.737

Z test Statistic = -8.75 | p(pooled) = 0.709
Critical Statistic = -1.645 | q(pooled) = 0.291

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

9. Difference in Proportions - Daily Saturday PC Data Set

$N_{(Before)}$ = 7,852 | $N_{(After)}$ = 7,840
Proportion Before = 0.613 | Proportion After = 0.676

Z test Statistic = -8.23 | p(pooled) = 0.644
Critical Statistic = -1.645 | q(pooled) = 0.356

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

10. Difference in Proportions - Daily Sunday PC Data Set

$N_{(Before)}$ = 7,345 | $N_{(After)}$ = 7,431
Proportion Before = 0.559 | Proportion After = 0.643

Z test Statistic = -10.47 | p(pooled) = 0.601
Critical Statistic = -1.645 | q(pooled) = 0.399

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

11. Difference in Proportions - TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ = 4,575 | $N_{(After)}$ = 5,482
Proportion Before = 0.583 | Proportion After = 0.669

Z test Statistic = -8.87 | p(pooled) = 0.630
Critical Statistic = -1.645 | q(pooled) = 0.370

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

12. Difference in Proportions - TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ = 3,121 $N_{(After)}$ = 2,861
Proportion Before = 0.400 Proportion After = 0.471

Z test Statistic = -5.51 p(pooled) = 0.434
Critical Statistic = -1.645 q(pooled) = 0.566

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

13. Difference in Proportions - TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ = 4,015 $N_{(After)}$ = 3,951
Proportion Before = 0.435 Proportion After = 0.527

Z test Statistic = -8.23 p(pooled) = 0.481
Critical Statistic = -1.645 q(pooled) = 0.519

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

14. Difference in Proportions - TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ = 4,981 $N_{(After)}$ = 4,994
Proportion Before = 0.428 Proportion After = 0.524

Z test Statistic = -9.52 p(pooled) = 0.476
Critical Statistic = -1.645 q(pooled) = 0.524

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

15. Difference in Proportions - TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ = 9,867 $N_{(After)}$ = 9,653
Proportion Before = 0.426 Proportion After = 0.548

Z test Statistic = -17.09 p(pooled) = 0.486
Critical Statistic = -1.645 q(pooled) = 0.514

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

16. Difference in Proportions - TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ = 10,096 $N_{(After)}$ = 9,878
Proportion Before = 0.544 Proportion After = 0.698

Z test Statistic = -22.46 p(pooled) = 0.620
Critical Statistic = -1.645 q(pooled) = 0.380

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

17. Difference in Proportions - TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ = 22,024 $N_{(After)}$ = 22,062
Proportion Before = 0.646 Proportion After = 0.763

Z test Statistic = -27.05 p(pooled) = 0.705
Critical Statistic = -1.645 q(pooled) = 0.295

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

18. Difference in Proportions - Weekday TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	2,673		$N_{(After)}$ =	3,215	
Proportion Before	=	0.539	Proportion After	=	0.649
Z test Statistic	=	-8.58	p(pooled)	=	0.600
Critical Statistic	=	-1.645	q(pooled)	=	0.400

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

19. Difference in Proportions - Weekday TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	1,995		$N_{(After)}$ =	1,807	
Proportion Before	=	0.392	Proportion After	=	0.476
Z test Statistic	=	-5.25	p(pooled)	=	0.432
Critical Statistic	=	-1.645	q(pooled)	=	0.568

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

20. Difference in Proportions - Weekday TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	2,424		$N_{(After)}$ =	2,247	
Proportion Before	=	0.439	Proportion After	=	0.500
Z test Statistic	=	-4.22	p(pooled)	=	0.468
Critical Statistic	=	-1.645	q(pooled)	=	0.532

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

21. Difference in Proportions - Weekday TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	2,882		$N_{(After)}$ =	2,853	
Proportion Before	=	0.400	Proportion After	=	0.513
Z test Statistic	=	-8.65	p(pooled)	=	0.456
Critical Statistic	=	-1.645	q(pooled)	=	0.544

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

22. Difference in Proportions - Weekday TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	5,633		$N_{(After)}$ =	5,662	
Proportion Before	=	0.380	Proportion After	=	0.519
Z test Statistic	=	-14.75	p(pooled)	=	0.450
Critical Statistic	=	-1.645	q(pooled)	=	0.550

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

23. Difference in Proportions - Weekday TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	5,751		$N_{(After)}$ =	5,720	
Proportion Before	=	0.434	Proportion After	=	0.634
Z test Statistic	=	-21.48	p(pooled)	=	0.534
Critical Statistic	=	-1.645	q(pooled)	=	0.466

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

24. Difference in Proportions - Weekday TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	12,565		$N_{(After)}$ =	12,410	
Proportion Before =	0.575		Proportion After =		0.759
Z test Statistic =	-30.81		p(pooled) =	0.666	
Critical Statistic =	-1.645		q(pooled) =	0.334	

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

25. Difference in Proportions - Weekend TOD 12 MN to 7 AM PC Data Set

$N_{(Before)}$ =	1,258		$N_{(After)}$ =	1,474	
Proportion Before =	0.715		Proportion After =		0.692
Z test Statistic =	1.29		p(pooled) =	0.702	
Critical Statistic =	-1.645		q(pooled) =	0.298	

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

26. Difference in Proportions - Weekend TOD 7 AM to 9 AM PC Data Set

$N_{(Before)}$ =	631		$N_{(After)}$ =	624	
Proportion Before =	0.464		Proportion After =		0.455
Z test Statistic =	0.33		p(pooled) =	0.460	
Critical Statistic =	-1.645		q(pooled) =	0.540	

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

27. Difference in Proportions - Weekend TOD 9 AM to 11 AM PC Data Set

$N_{(Before)}$ =	1,011		$N_{(After)}$ =	1,051	
Proportion Before =	0.459		Proportion After =		0.584
Z test Statistic =	-5.69		p(pooled) =	0.523	
Critical Statistic =	-1.645		q(pooled) =	0.477	

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

28. Difference in Proportions - Weekend TOD 11 AM to 1 PM PC Data Set

$N_{(Before)}$ =	1,303		$N_{(After)}$ =	1,381	
Proportion Before =	0.535		Proportion After =		0.550
Z test Statistic =	-0.80		p(pooled) =	0.543	
Critical Statistic =	-1.645		q(pooled) =	0.457	

Hence: Accept Ho - Conclude 35 + 5 mph Speed Compliance is not increased

29. Difference in Proportions - Weeend TOD 1 PM to 4 PM PC Data Set

$N_{(Before)}$ =	2,675		$N_{(After)}$ =	2,563	
Proportion Before =	0.471		Proportion After =		0.574
Z test Statistic =	-7.43		p(pooled) =	0.522	
Critical Statistic =	-1.645		q(pooled) =	0.478	

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

30. Difference in Proportions - Weekend TOD 4 PM to 6 PM PC Data Set

$N_{(Before)}$ =	2,246	$N_{(After)}$ =	2,229
Proportion Before =	0.544	Proportion After =	0.645
Z test Statistic =	-6.91	p(pooled) =	0.594
Critical Statistic =	-1.645	q(pooled) =	0.406

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

31. Difference in Proportions - Weekend TOD 6 PM to 12 MN PC Data Set

$N_{(Before)}$ =	6,073	$N_{(After)}$ =	5,949
Proportion Before =	0.672	Proportion After =	0.754
Z test Statistic =	-10.02	p(pooled) =	0.713
Critical Statistic =	-1.645	q(pooled) =	0.287

Hence: Reject Ho - Conclude 35 + 10 mph Speed Compliance is increased

HYPOTHESIS TEST FOR A DIFFERENCE IN MEANS - PC SPEED DATA
SPEED RANGES

To determine if the mean speed of vehicles traveling in the speed ranges decreased after DSM installation.

Ho: $\text{Mean}_{(before)} - \text{Mean}_{(after)} = 0$ **Ha: $\text{Mean}_{(before)} - \text{Mean}_{(after)} > 0$**

Reject Ho if t test statistic > Critical statistic; 95% significance level

1. Difference in Means - 1 to 35 Speed Range PC Data Set

$N_{(Before)}$ = 2,977 — $N_{(After)}$ = 5,308
Mean Before = 32.245 — Mean After = 32.640
Variance Before = 10.131 — Variance After = 7.579

t test Statistic = -5.673 — Deg. of Free, υ = 5458
Critical Statistic = 1.645

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

2. Difference in Means - 36 to 47 Speed Range PC Data Set

$N_{(Before)}$ = 40,082 — $N_{(After)}$ = 43,195
Mean Before = 42.411 — Mean After = 41.868
Variance Before = 8.775 — Variance After = 9.245

t test Statistic = 26.105 — Deg. of Free, υ = 83078
Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

3. Difference in Means - 48 to 59 Speed Range PC Data Set

$N_{(Before)}$ = 15,423 — $N_{(After)}$ = 10,289
Mean Before = 50.716 — Mean After = 50.486
Variance Before = 5.463 — Variance After = 4.748

t test Statistic = 8.062 — Deg. of Free, υ = 23074
Critical Statistic = 1.645

Hence: Reject Ho - Conclude Mean Speed Reduction is Significant

4. Difference in Means - 60 to 147Speed Range PC Data Set

$N_{(Before)}$ = 197 — $N_{(After)}$ = 89
Mean Before = 62.259 — Mean After = 62.045
Variance Before = 5.562 — Variance After = 4.942

t test Statistic = 0.739 — Deg. of Free, υ = 179
Critical Statistic = 1.645

Hence: Accept Ho - Conclude Mean Speed Reduction is not Significant

HYPOTHESIS TEST FOR A DIFFERENCE IN PROPORTIONS - PC SPEED DATA
SPEED RANGES

To determine if the proportion of drivers in the lower speed ranges increased and the proportion of drivers in the upper speed ranges decreased after DSM installation.

Lower Ranges: **Ho: $Proportion_{(before)}$ - $Proportion_{(after)}$ = 0** **Ha: $Proportion_{(before)}$ - $Proportion_{(after)}$ < 0**

Upper Ranges: **Ho: $Proportion_{(before)}$ - $Proportion_{(after)}$ = 0** **Ha: $Proportion_{(before)}$ - $Proportion_{(after)}$ > 0**

Reject Ho if Z statistic test < Critical statistic; 95% significance level

1. Difference in Proportions - 1 to 35 Speed Range PC Data Set

$N_{(Before)}$ =	2,977	$N_{(After)}$ =	5,308
Proportion Before =	0.051	Proportion After =	0.090
Z test Statistic =	-6.50	p(pooled) =	0.076
Critical Statistic =	-1.645	q(pooled) =	0.924

Hence: Reject Ho - Conclude Proportion in After Speed Range is Increased

2. Difference in Proportions - 36 to 47 Speed Range PC Data Set

$N_{(Before)}$ =	40,082	$N_{(After)}$ =	43,195
Proportion Before =	0.683	Proportion After =	0.734
Z test Statistic =	-16.04	p(pooled) =	0.709
Critical Statistic =	-1.645	q(pooled) =	0.291

Hence: Reject Ho - Conclude Proportion in After Speed Range is increased

3. Difference in Proportions - 48 to 59 Speed Range PC Data Set

$N_{(Before)}$ =	15,423	$N_{(After)}$ =	10,289
Proportion Before =	0.263	Proportion After =	0.175
Z test Statistic =	16.51	p(pooled) =	0.228
Critical Statistic =	1.645	q(pooled) =	0.772

Hence: Reject Ho - Conclude Proportion in After Speed Range is decreased

4. Difference in Proportions - 60 to 147Speed Range PC Data Set

$N_{(Before)}$ =	197	$N_{(After)}$ =	89
Proportion Before =	0.003	Proportion After =	0.002
Z test Statistic =	0.27	p(pooled) =	0.003
Critical Statistic =	1.645	q(pooled) =	0.997

Hence: Reject Ho - Conclude Proportion in After Speed Range is decreased (using Chi-Squared Distribuition)

HYPOTHESIS TEST FOR A DIFFERENCE IN VARIANCE - PC SPEED DATA

To determine if the speed variance decreased after DSM installation.

Ho: $Variance_{(before)} - Variance_{(after)} = 0$ Ha: $Variance_{(before)} - Variance_{(after)} > 0$

Reject Ho if Fstatistic > Critical statistic; 95% significance level

<u>1. Difference in Means - 1 to 35 Speed Range PC Data Set</u>

$N_{(Before)}$ = 2,977 | $N_{(After)}$ = 5,308
Variance Before = 10.131 | Variance After = 7.579

F Statistic = 1.337 | Deg. of Free 1, υ_1 = 2976
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 5307

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

<u>2. Difference in Proportions - 36 to 47 Speed Range PC Data Set</u>

$N_{(Before)}$ = 40,082 | $N_{(After)}$ = 43,195
Variance Before = 8.775 | Variance After = 9.245

F Statistic = 0.949 | Deg. of Free 1, υ_1 = 40081
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 43194

Hence: Accept Ho - Conclude Speed Variance Reduction is not Significant

<u>3. Difference in Proportions - 48 to 59 Speed Range PC Data Set</u>

$N_{(Before)}$ = 15,423 | $N_{(After)}$ = 10,289
Variance Before = 5.463 | Variance After = 4.748

F Statistic = 1.151 | Deg. of Free 1, υ_1 = 15422
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 10288

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

<u>4. Difference in Proportions - 60 to 147Speed Range PC Data Set</u>

$N_{(Before)}$ = 197 | $N_{(After)}$ = 89
Variance Before = 5.562 | Variance After = 4.942

F Statistic = 1.126 | Deg. of Free 1, υ_1 = 196
Critical Statistic = 1.00 | Deg. of Free 2, υ_2 = 88

Hence: Reject Ho - Conclude Speed Variance Reduction is Significant

BEFORE AND AFTER APPROACH SPEED COMPARISON

Data Set No.	Test No.	DATA SET		Mean		Variance		% Obeying Advisory Speed (35 mph)		% Obeying Speed Limit + 5 Mph		% Obeying Advisory Speed +10 Mph		85th Percentile		Coefficient of Variation	
				Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	1	Entire		44.15	42.58	29.92	29.22	5.07	9.01	29.24	40.80	54.04	65.79	47.0	46.0	0.12	0.13
2	2	Day Time		44.85	43.11	28.60	29.42	3.59	7.81	24.01	35.99	48.40	61.39	47.0	46.0	0.12	0.13
3	3	Night Time		42.29	41.24	28.71	26.23	9.04	12.00	43.25	52.77	69.13	76.70	46.0	44.0	0.13	0.12
3	4	Daily	Monday	44.04	42.78	25.44	28.30	4.09	8.20	28.46	39.08	55.72	64.56	47.0	46.0	0.11	0.12
	5		Tuesday	45.02	42.74	30.66	28.26	3.72	8.03	24.10	39.06	46.83	64.89	50.0	46.0	0.12	0.12
	6		Wednesday	45.37	43.89	28.77	26.16	3.17	4.86	21.25	29.71	44.55	56.45	49.0	47.0	0.12	0.12
	7		Thursday	45.16	42.44	28.50	28.35	3.51	8.59	22.29	41.92	45.31	67.56	47.0	46.0	0.12	0.13
	8		Friday	42.34	41.02	34.92	32.87	10.13	16.52	44.06	53.31	67.97	73.70	46.0	44.0	0.14	0.14
	9		Saturday	43.23	42.58	27.00	26.94	6.21	7.81	34.59	41.38	61.27	67.56	46.0	46.0	0.12	0.12
	10		Sunday	44.03	42.88	24.74	28.18	3.99	7.67	28.47	38.85	55.86	64.30	47.0	46.0	0.11	0.12
4	11	Time of Day	12 MN to 7 AM	43.64	42.70	33.42	28.24	6.67	7.64	34.34	40.77	58.34	66.91	47.0	46.0	0.13	0.12
	12		7 AM to 9 AM	46.02	44.93	30.14	27.01	2.50	2.94	18.81	23.94	40.02	47.08	49.0	47.0	0.12	0.12
	13		9 AM to 11 AM	45.42	44.36	27.19	23.96	3.11	3.26	19.75	25.59	43.54	52.75	49.0	47.0	0.11	0.11
	14		11 AM to 1 PM	45.54	44.43	27.95	24.23	2.67	3.30	19.98	25.91	42.84	52.36	49.0	47.0	0.12	0.11
	15		1 PM to 4 PM	45.59	44.03	25.86	27.08	2.36	4.86	18.35	29.44	42.56	54.78	49.0	47.0	0.11	0.12
	16		4 PM to 6 PM	44.02	41.80	29.43	32.44	4.88	13.09	29.02	45.79	54.39	69.81	47.0	46.0	0.12	0.14
	17		6 PM to 12 MN	42.87	41.21	28.28	26.19	7.31	12.46	38.47	51.84	64.57	76.33	46.0	44.0	0.12	0.12
5	18	Weekday Time of Day	12 MN to 7 AM	44.29	42.96	30.93	27.21	4.26	6.56	29.82	38.79	53.95	64.95	47.0	46.0	0.13	0.12
	19		7 AM to 9 AM	46.05	44.95	30.66	26.60	2.56	2.77	18.55	23.85	39.20	47.65	49.0	47.0	0.12	0.11
	20		9 AM to 11 AM	45.28	44.61	28.87	24.47	3.80	3.20	21.37	23.01	43.85	50.02	47.0	47.0	0.12	0.11
	21		11 AM to 1 PM	45.89	44.54	27.79	25.75	2.08	3.54	18.29	25.59	39.97	51.35	49.0	47.0	0.11	0.11
	22		1 PM to 4 PM	46.14	44.40	25.96	25.69	1.62	3.74	15.76	26.49	38.04	51.85	49.0	47.0	0.11	0.11
	23		4 PM to 6 PM	45.37	42.94	24.33	27.72	2.52	7.64	19.79	36.14	43.44	63.44	47.0	46.0	0.11	0.12
	24		6 PM to 12 MN	43.78	41.34	28.54	25.77	5.37	11.61	31.06	50.23	57.46	75.85	47.0	44.0	0.12	0.12
6	25	Weekend Time of Day	12 MN to 7 AM	41.62	42.37	33.34	31.64	13.04	10.31	48.17	43.49	71.46	69.20	44.0	46.0	0.14	0.13
	26		7 AM to 9 AM	45.41	44.95	26.31	27.12	2.06	2.88	21.87	23.72	46.43	45.51	49.0	47.0	0.11	0.12
	27		9 AM to 11 AM	45.21	43.88	22.49	22.55	1.98	3.04	18.99	31.21	45.90	58.42	47.0	46.0	0.10	0.11
	28		11 AM to 1 PM	44.13	44.13	23.27	22.29	4.53	3.11	24.71	28.10	53.49	55.03	47.0	47.0	0.11	0.11
	29		1 PM to 4 PM	44.99	43.92	23.27	25.58	2.47	4.21	20.90	29.89	47.14	57.39	47.0	47.0	0.11	0.12
	30		4 PM to 6 PM	44.24	43.13	22.77	25.55	2.85	5.16	25.65	37.01	54.36	64.51	47.0	46.0	0.11	0.12
	31		6 PM to 12 MN	42.64	41.39	24.63	26.61	6.50	12.00	39.75	51.02	67.17	75.44	46.0	44.0	0.12	0.12

Data Set No.	Test No.	DATA SET		Mean		Variance		Proportion of Total Vehicles		Coefficient of variation	
								Before	After		
7	32	Speed Range	1 to 35	32.25	32.64	10.13	7.58	0.051	0.090	0.10	0.08
	33		36 to 47	42.41	41.87	8.78	9.25	0.683	0.73	0.070	0.073
	34		48 to 59	50.72	50.49	5.46	4.75	0.263	0.17	0.046	0.043
	35		60 to 147	62.26	62.04	5.56	4.94	0.003	0.00	0.038	0.036

Data Set No.	Test No.	DATA SET		Proportion			Frequency		
				Before	After	Diff.	Before	After	Diff.
8	36	Higher Speed Range	**45 to 47**	19.34	16.59	2.75	11348	9766	1582
	37		**48 to 50**	15.19	10.85	4.34	8913	6386	2527
	38		**51 to 53**	7.98	5.01	2.97	4681	2947	1734
	39		**54 to 56**	2.30	1.22	1.07	1347	720	627
	40		**57 to 59**	0.82	0.40	0.42	482	236	246
	41		**60 to 147**	0.34	0.15	0.18	197	89	108

- Indicates no significant reduction at the 95% confidence level

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